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THE PENNSYLVANIA
STATE UNIVERSITY

IONOSPHERIC RESEARCH

Scientific Report (E) No. 181

ROCKET INSTRUMENTATION FOR THE MEASUREMENT OF AC CONDUCTIVITY, WITH A CAPACITIVE PROBE, AND LONG WAVE PROPAGATION IN THE LOWER IONOSPHERE

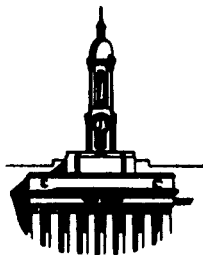
by

T. A. Seliga and R. W. Vogt

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IONOSPHERE RESEARCH LABORATORY



University Park, Pennsylvania

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Ionospheric Research

Contract AF19(604)-8012

Scientific Report

on

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Submitted by:

J. S. Nisbet (aw)
J. S. Nisbet, Assistant Professor of
Electrical Engineering,
Project Supervisor

Approved by:

A. H. Waynick
A. H. Waynick, Professor of Electrical
Engineering, Director, IRL

THE PENNSYLVANIA STATE UNIVERSITY
College of Engineering
Department of Electrical Engineering

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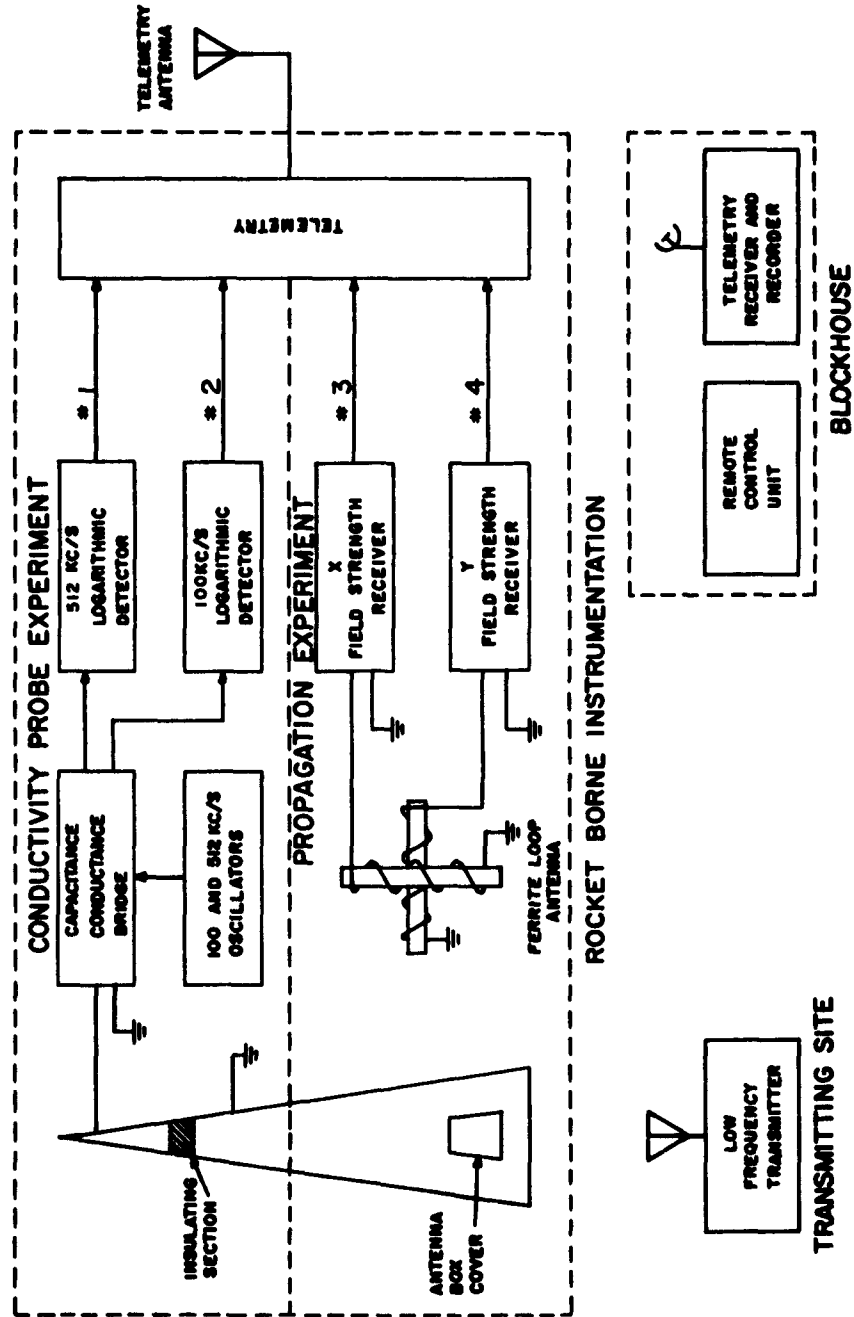
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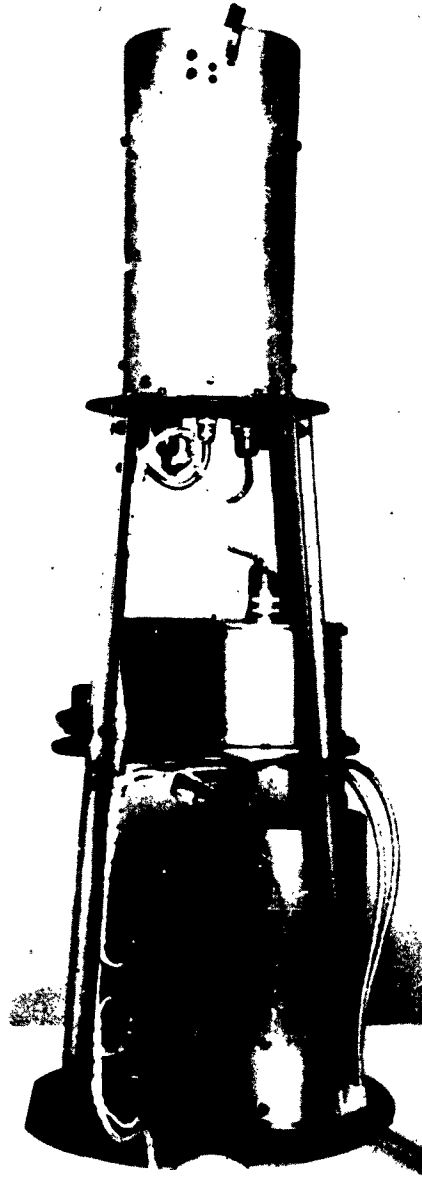
1. Introduction

This report summarizes the mechanical and electrical characteristics of instrumentation designed to be flown in a Black Brant (AA17.199) rocket along with another payload developed by AFCRL. The experiments for which the instrumentation is used are: a) an A-C conductivity probe which measures the impedance between an insulated section of the nose cone and the body of the rocket at two different frequencies, and b) a propagation experiment which measures the field strength, along two axes of the rocket, of a low frequency wave transmitted from the ground to the rocket.

A block diagram of the system used to perform the experiments is given in Figure 1. Figure 2 is a photograph of the instrumentation mounted on its rack. Figure 3 shows the rocket nose cone illustrating the insulating ring, a cover which allows access to the conductivity experiment instrumentation, and an antenna box cover behind which is mounted two mutually perpendicular ferrite loop antennas in an aluminum housing.



IRL PROBE EXPERIMENT
FIGURE 1



INSTRUMENTATION MOUNTED ON ITS RACK

FIGURE 2

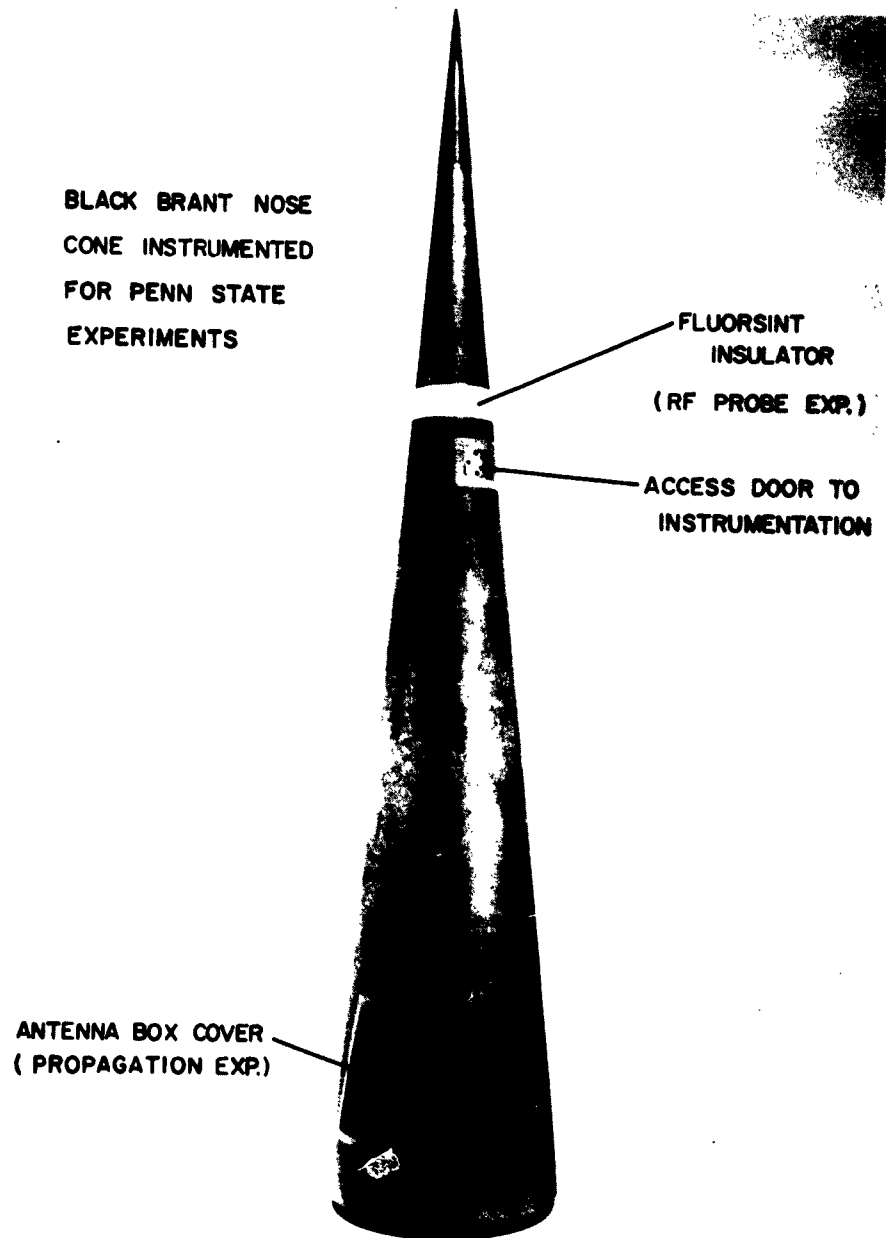


FIGURE 3

2.0 Conductivity Probe Experiment

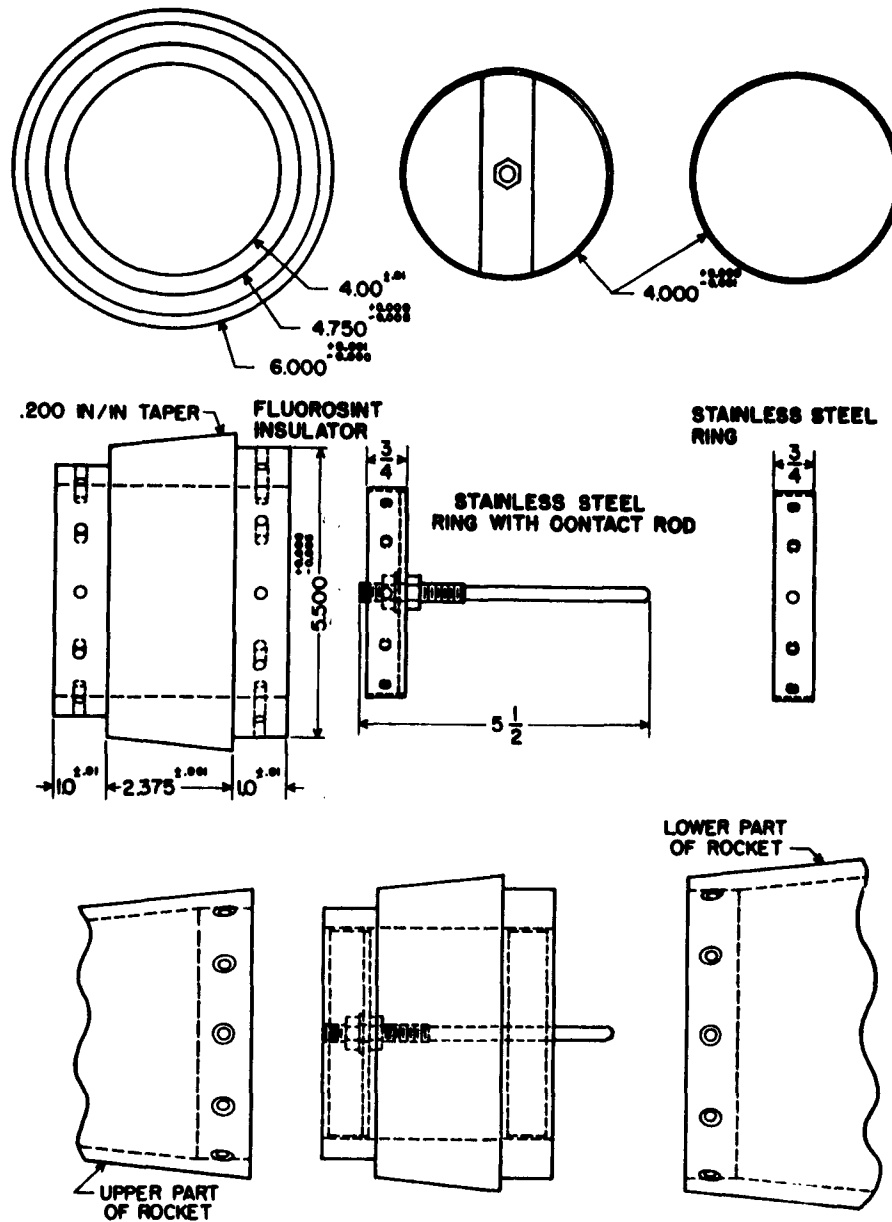
The conductivity experiment consists of an insulated section of the nose cone, a dual oscillator source, a capacitance-conductance bridge, and two logarithmic detectors whose outputs feed telemetry channels 1 and 2 (22 kc/s and 70 kc/s channels; respectively). It is designed to measure the A.C. conductivity and capacitance between two insulated sections of the rocket as the rocket passes through the ionosphere. The measurements are made at 100 and 512 kc/s. These frequencies were chosen, because the theoretical impedance characteristics indicate a radical change in behavior for frequencies on either side of $f = 300 \text{ kc/s.}^1$

2.1 Nose Cone Insulating Ring

An assembly drawing of the nose cone insulator is given in Figure 4. The insulating material is fluorosint, a product of the Polymer Corporation, Reading, Pa., and was chosen because of its extraordinary mechanical, electrical, and thermal characteristics. These characteristics are presented below:

Mechanical Properties		
Tensile strength, 73°F		750-2500 P.S.I.
Elongation, 73°F		10-200%
Modulus of Elasticity, 73°F		190,000 P.S.I.
Hardness, Rockwell, 73°F		R 50-55
	Durometer, 73°F	D 70-75
Specific Gravity		2.2-2.4
Coefficient of Linear Thermal Expansion		$1.1 \times 10^{-5} \text{ in./in./}^\circ\text{F}$
Deformation Under Load		
	200°F, 1200 P.S.I.	0.2%
	500°F, 1200 P.S.I.	1.2%
Melting Point		621 \pm 9°F

1. Herman J., Scientific Report No. 180.,



NOSE CONE INSULATION AND ASSEMBLY

FIGURE 4

Electrical Properties

Dielectric Strength	300-400 volts/mil.
Short time (0.080 in. thickness)	
Volume Resistivity	10^{15} ohm-cm.
Dielectric Constant 0- 10^8 cps.	3.3-3.45
Power Factor 0- 10^8 cps.	0.0005-0.0010

A stainless steel conductor is connected to the upper portion of the nose cone through a ring which is mounted on the inside of the insulator. Electrical contact from the stainless steel conductor to the nose cone is made through the mounting screws which support the upper part of the nose cone. The bridge detector is connected to the stainless steel conductor by means of a female connector mounted on the top of the bridge detector assembly unit.

2.2.0 Oscillators

The 100 kc/s and 512 kc/s oscillators are transistorized modified Colpitts types, incorporating a crystal of appropriate frequency in the feedback loop. Fig. 5. is a circuit diagram of both oscillators, individual buffer stages and an adder emitter-follower. Resistance-capacitance coupling is used between the buffer stage of each oscillator and the emitter-follower where the two frequencies are added.

The voltage output from the emitter-follower is variable over a wide empirical range by selection of the values of R 9 and R 19. The advantage of this type of adjustment is that differences in the characteristics of the crystals, transistors and accumulative tolerances of inductive, resistive and capa-

citive components, which affect the oscillator-buffer voltage output, are easily compensated for by making single resistance adjustments.

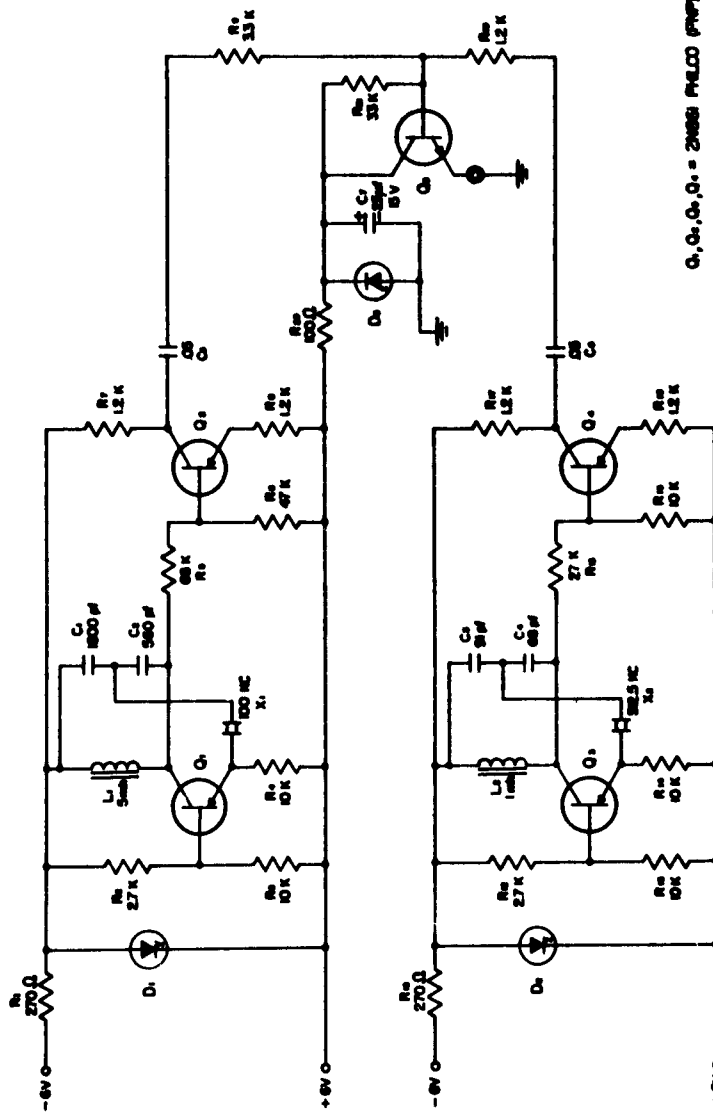
Collector supply voltage for all stages is Zener regulated.

2.2.1 Packaging

The oscillator units are assembled on printed circuit boards as shown in Figure 6. The units are epoxied with a clear epoxy to prevent any mechanical malfunction during the flight of the rocket. The oscillators' assembly is fastened to an aluminum housing and completely encapsulated in eccofoam; this provides some thermal insulation and additional mechanical support for the components.

2.2.2 Characteristics

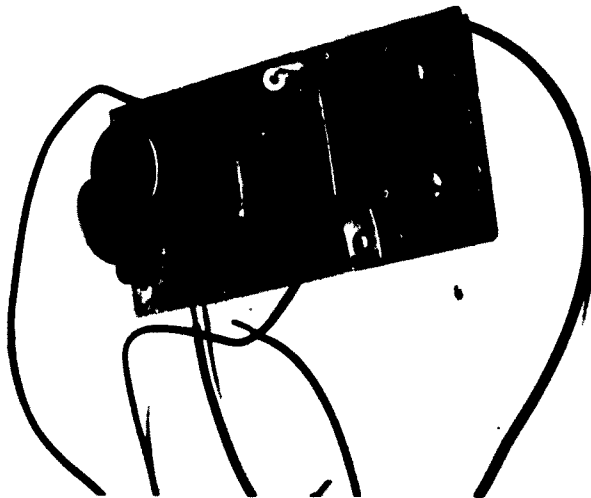
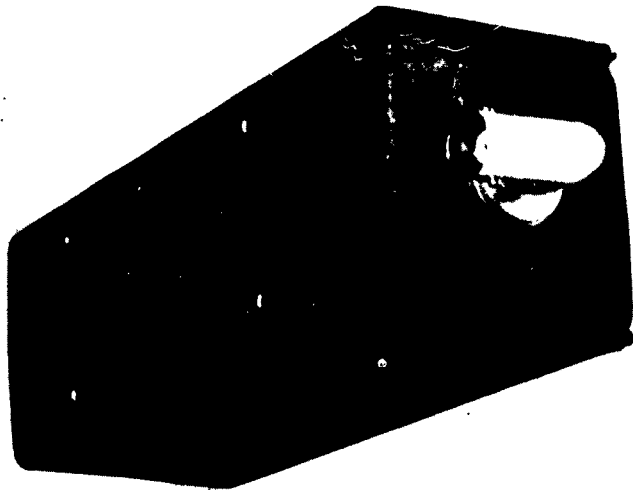
- 1) Input Voltage - plus and minus 6 volts DC
- 2) Input Current - 20 ma at +6V, 10 ma at -6V
- 3) Output Voltage - 1 volt p-p 512 kc/s
1 volt p-p 100 kc/s
- 4) Voltage Stability - 512 kc/s 11% incr. -40° to +30°C
11% incr. 30 to 80°C
100 kc/s 8.8% incr. -40° to +30°C
8.8% incr. 30 to 80°C
- 5) Frequency Stability - 512 kc/s .65% -40° to +80°C
100 kc/s .05% -40° to +80°C



Q₁, Q₂, Q₃, Q₄ = 2N4581 PNP (PNP)
 Q₅ = 2N4582 TRANSISTOR (PNP)
 D₁, D₂ = 1N753 HOFFMAN V_F = 9.5 V
 D₃ = 1N705 SILICON V_F = 4.8 V
 ALL RESISTORS 1/4 W

OSCILLATOR SCHEMATIC DIAGRAM

FIGURE 5



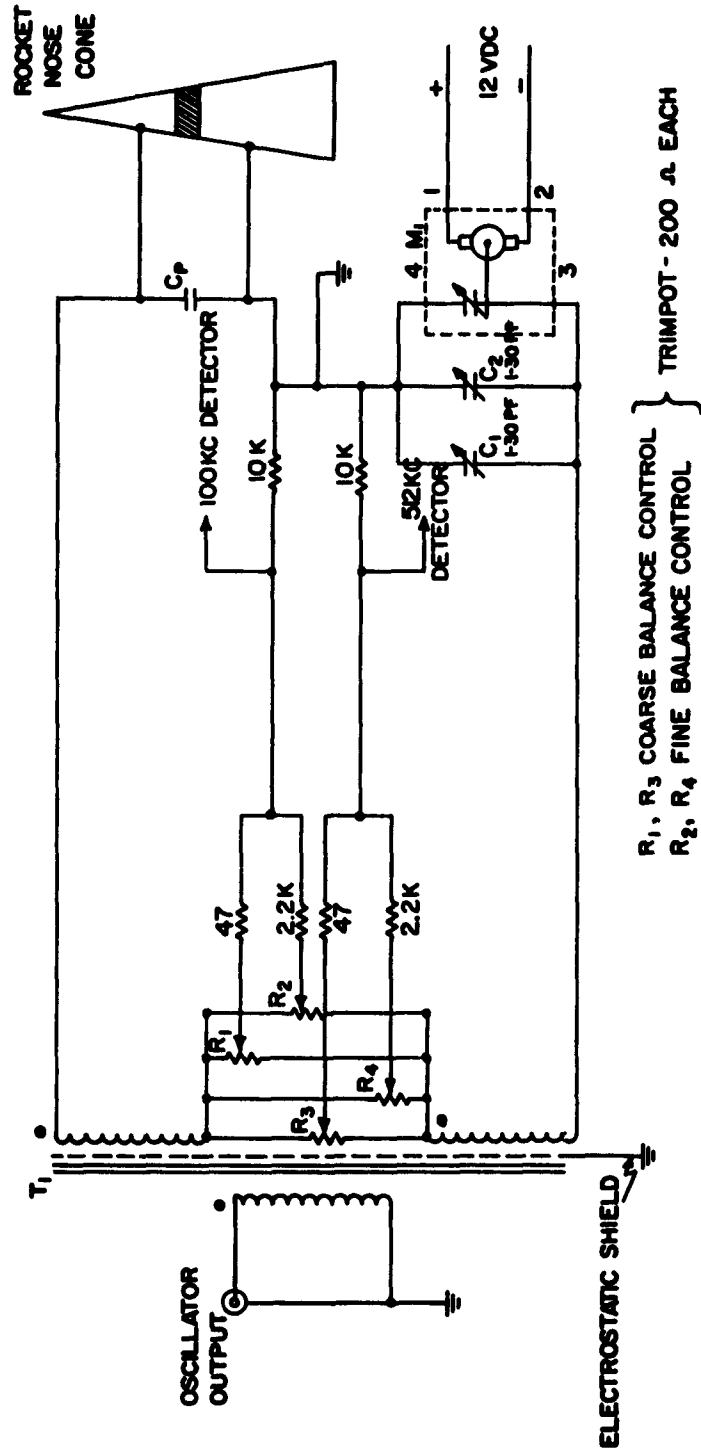
OSCILLATOR ASSEMBLY

FIGURE 6

2.3.0 Bridge

Figure 7 is a circuit diagram of the bridge. The circuit is basically a capacitance bridge, as no provision is made to null the conductive component of the detector voltage which appears across the (unknown) probe. The bridge circuit is not frequency dependent, and measurements are made at two frequencies: 100 kc/s and 512 kc/s. The output voltages of two crystal controlled transistorized oscillators are added and applied to the bridge transformer. The output impedance of the bridge transformer is such that it appears to be an ideal voltage source which has a voltage amplitude of 1 volt peak to peak referred to the center tap. The capacitance between the insulated portions of the rocket acts as the unknown.

The known capacitance is a small (3 to 30 pf) variable air dielectric capacitor which is driven by a small DC motor at a speed of 100 r.p.m. This motor speed corresponds to 0.6 cycles per second, and during each cycle the bridge is swept through two null points. Assuming that the unknown is purely capacitive a null corresponds to zero volts. Should the unknown capacitor be lossy, that, is, have a conductive component, the voltage of the null is then dependent upon the conductivity of the unknown across the nosecone insulator. Thus, two measurements are made: 1) a capacitance measurement which is a function of time and depends upon the motor speed appears as the separation in time between adjacent nulls, 2) the conductive measurement which is a function of voltage is



CAPACITANCE - CONDUCTANCE
BRIDGE CKT DIAGRAM

FIGURE 7

made by comparing the null voltage with a calibrated null voltage (obtained by placing known conductances across the insulator).

The output of the bridge feeds two logarithmic detectors, one of which is tuned to 100 kc/s and the other to 512 kc/s.

2.3.1 Bridge Balancing

Bridge balancing is accomplished for each detector by means of a potentiometer arrangement as indicated in Figure 7. With this configuration both course and fine balance adjustments are possible. Because of interaction between fine adjustments near the nulls, a compromise setting of the controls is necessary. Of course, it is possible to balance the bridge at either frequency and accept an unbalance of the other.

2.3.2 Transformer Characteristics

The turns ratio of the transformer is 1:2, primary to secondary. The secondary is center-tapped to provide equal voltages to both arms of the bridge. The primary is first wound on the bobbin insert with 25 turns of No. 32 nyclad wire. A layer of glass tape, an electrostatic shield (.001 in. brass shim stock), and another layer of glass tape are wrapped around the primary, being careful not to cause a shorted turn. The secondary is then bifilar wound with 25 turns over the shield, and all the necessary leads are brought

out to a teflon terminal board. The entire transformer is potted in a synthetic rubber sealing compound (Products Research Co.; PR-1201-Q) to protect it from humidity, temperature changes, and mechanical shock.

The inductance of the primary and half of the secondary is approximately 200 μ h. The measured unloaded Q of the primary and secondary is approximately 60 over the frequency range 100 kc/s to 512 kc/s.

Because of the small losses in the transformer at both frequencies, and the impedances presented by the arms of the bridge to the transformer, the transformer is nearly ideal at both frequencies. The result of this is to have the same balance position for both frequencies.

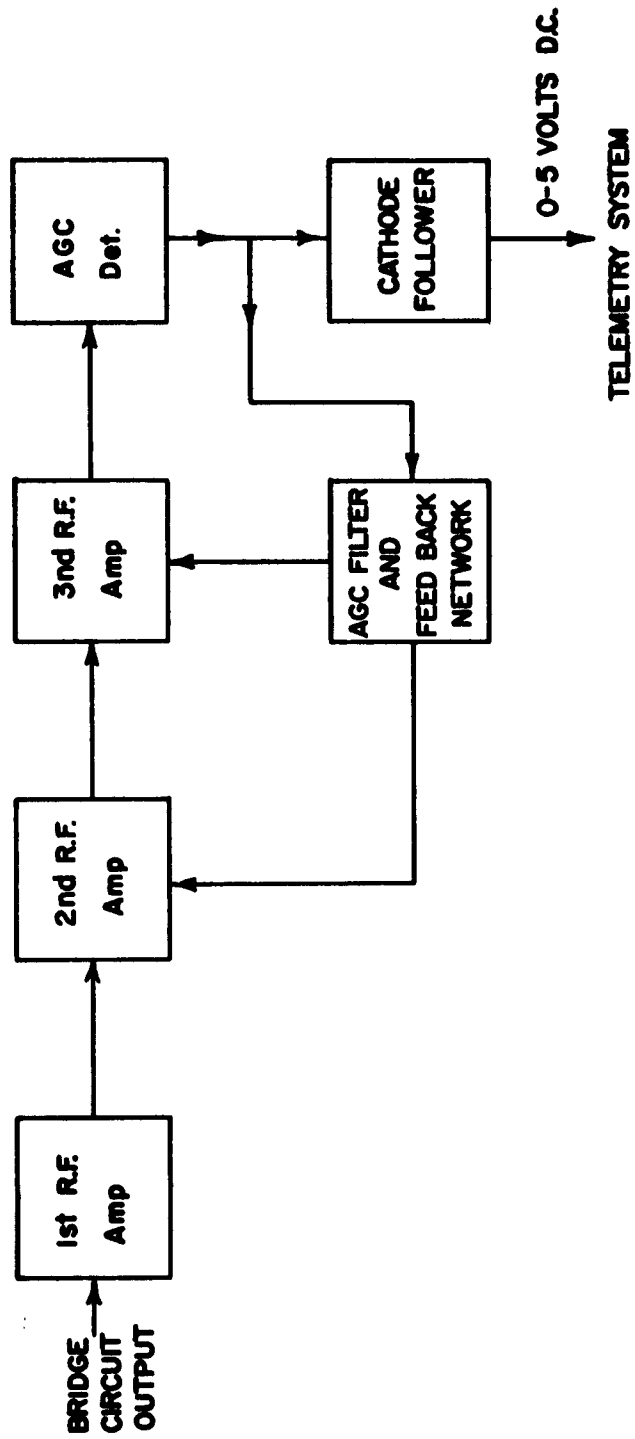
2.3.3 Packaging

The bridge circuit, excluding the motor-driven capacitor, is mounted on a rigid aluminum shelf located in the upper part of the capacity probe unit. Two hermetically sealed variable capacitors which are connected in parallel with the motor-driven capacitor are mounted in a teflon block, the ends of which have been etched (carbonized) and sealed with epoxy. This prevents any leakage due to humidity from occurring across these capacitors. The teflon block and the epoxy also provide a rigid mounting for the capacitors and reduce the likelihood of their breaking due to vibration. Four trimpots which comprise the coarse and fine balance controls are mounted on the shelf such that their electrical adjustment along with

that of the variable capacitors are accessible through an opening in the shelf. Connections to the top part of the insulated part of the nosecone is made via a stainless steel rod to a modified Amphenol female type connector. A braided connection wire from the modified connector to the bridge is used to reduce the effects of vibration. The entire shelf is potted in eccof foam which gives added rigidity to the component parts and gives further protection from temperature and humidity effects.

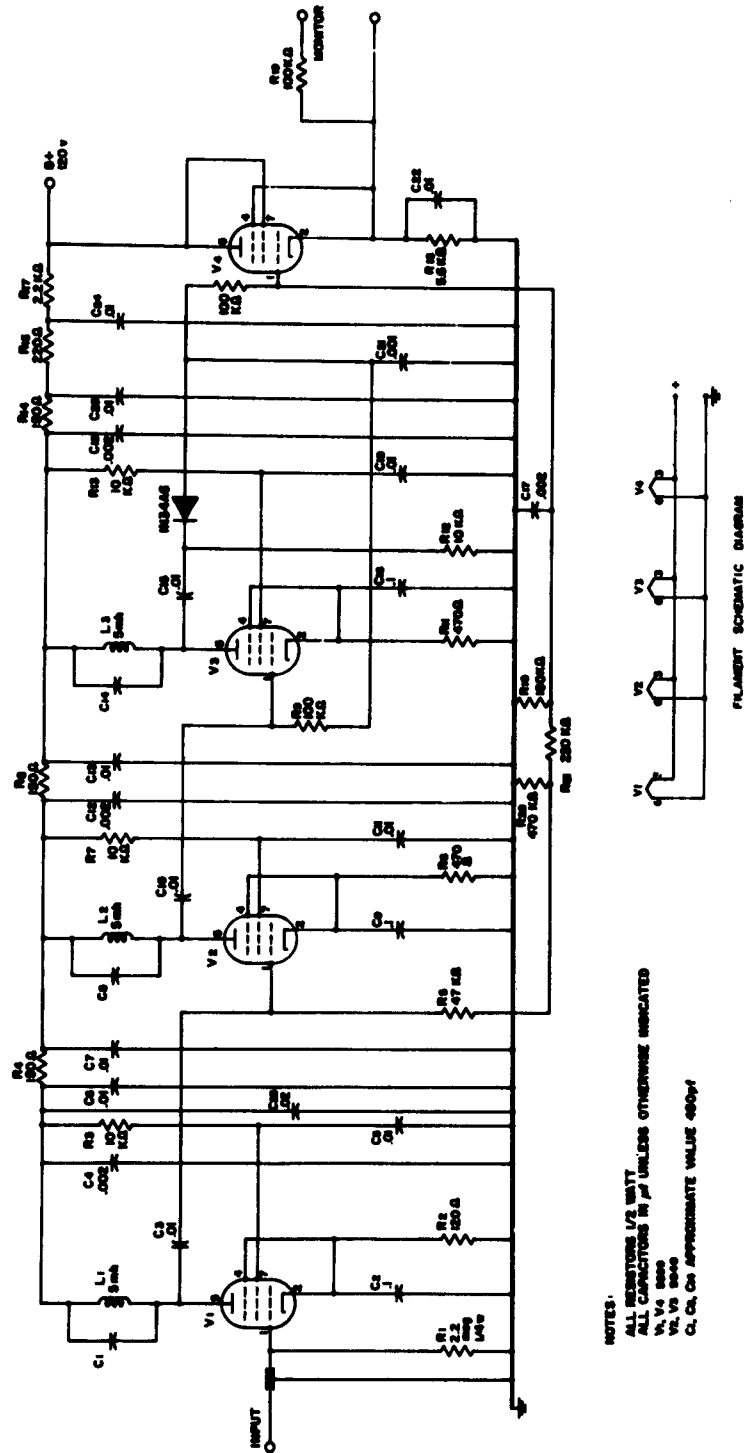
2.4.0 Detectors

The detectors consist of three fix-tuned RF amplifier stages, a diode detector with feed-back providing AGC to two of the stages and a cathode follower output as shown in Figure 8. They were designed to have logarithmic output characteristics with input voltage. These detectors were originally used for the REDD Rocket project and later modified for use as detector amplifiers according to the needs of the probe project. The original REDD detectors included a crystal filter stage which was eliminated for the present use. Widening of the AGC bandwidth was also required to permit the AGC to follow the bridge output waveform which contains frequency components on the order of 2 kc/s. Five-star sub-miniature missile type tubes are used because of their small size and resistance to vibration. The circuit diagrams for the 100 kc/s and 512 kc/s detectors are shown in Figures 9 and 10. The relationship between bandwidth and input level for the 100 kc/s and the



BLOCK DIAGRAM OF 100K % AND 512K % DETECTORS

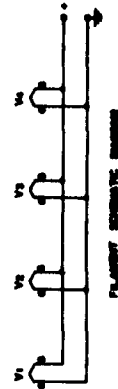
FIGURE 8



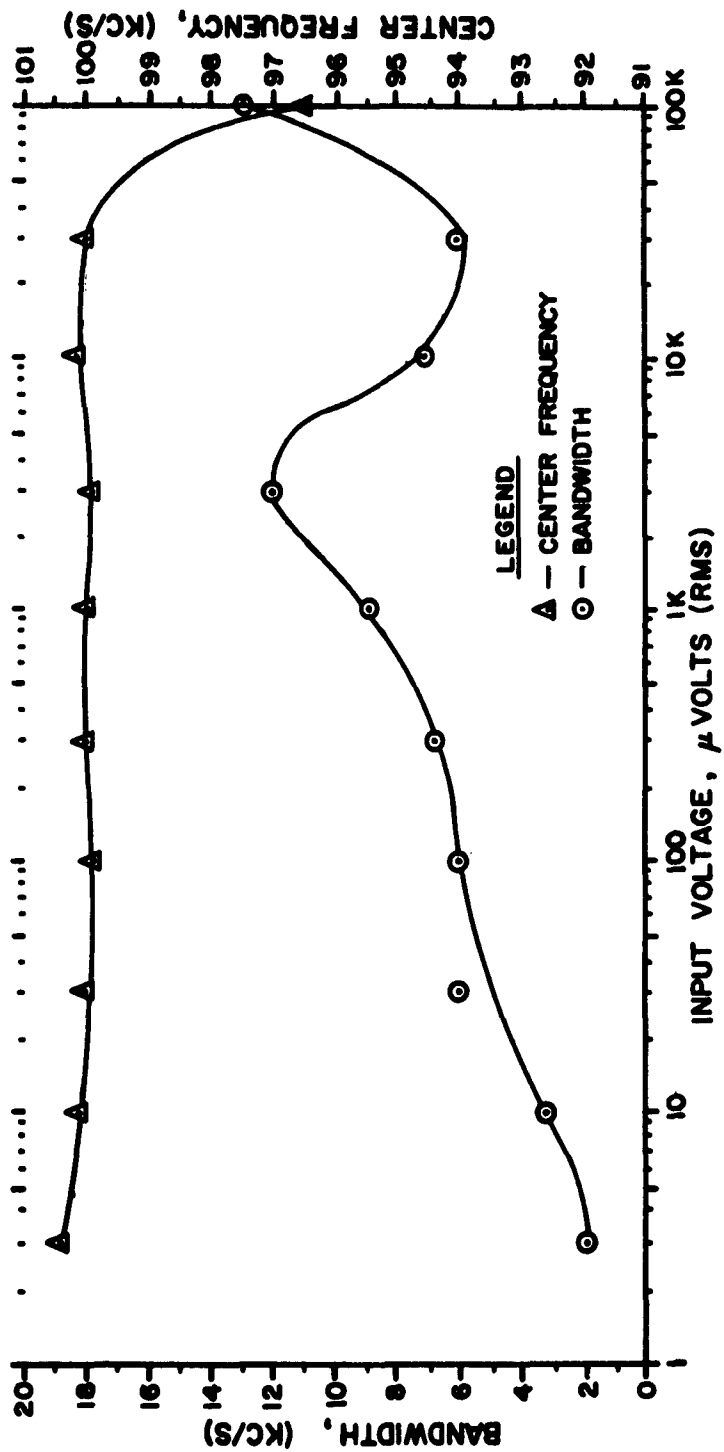
SCHEMATIC DIAGRAM OF 100 Mc/s DETECTOR
FIGURE 9

NOTES:
ALL RESISTORS 1/2 WATT AND
ALL CAPACITORS IN μ UNLESS
OTHERWISE INDICATED.
C1, C2 APPROXIMATE VALUE 40pF

0005 6474
0005 6474

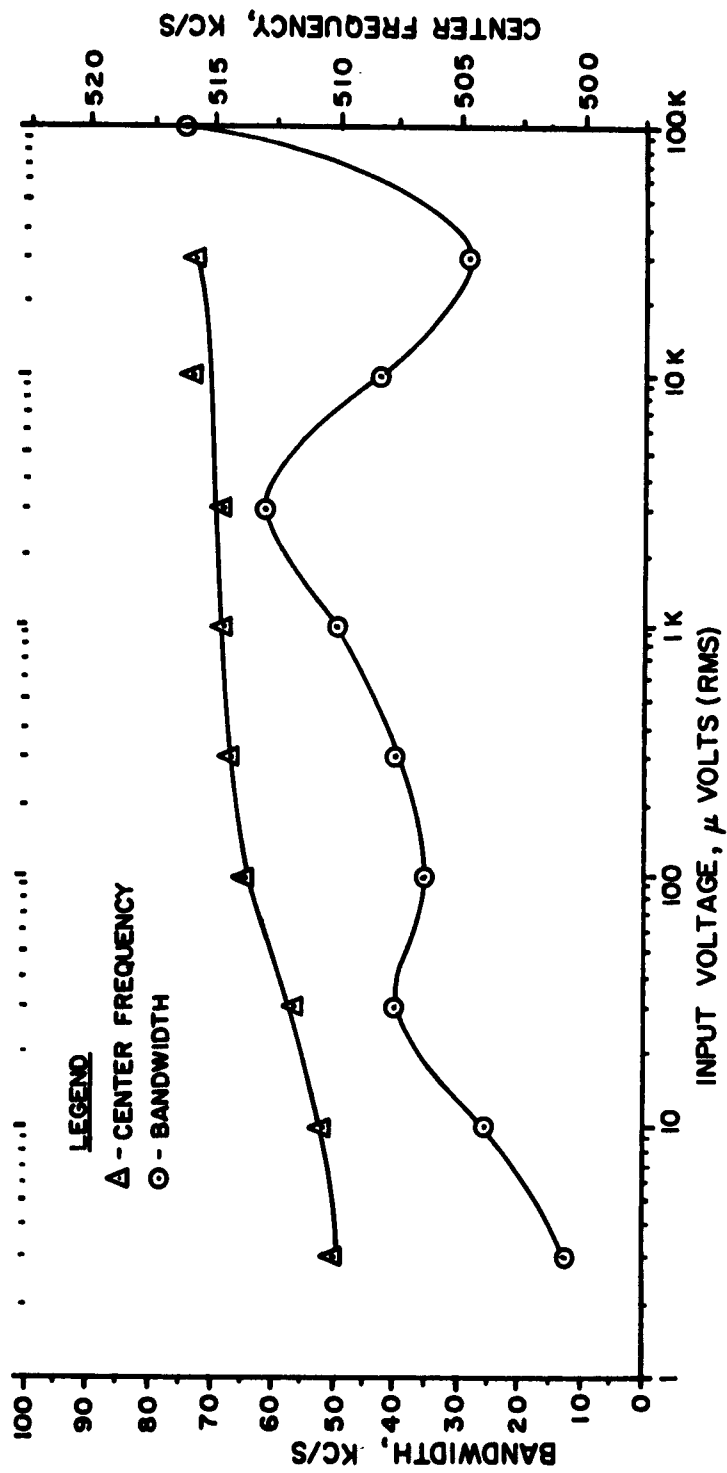


SCHEMATIC DIAGRAM OF 502 KC/S DETECTOR



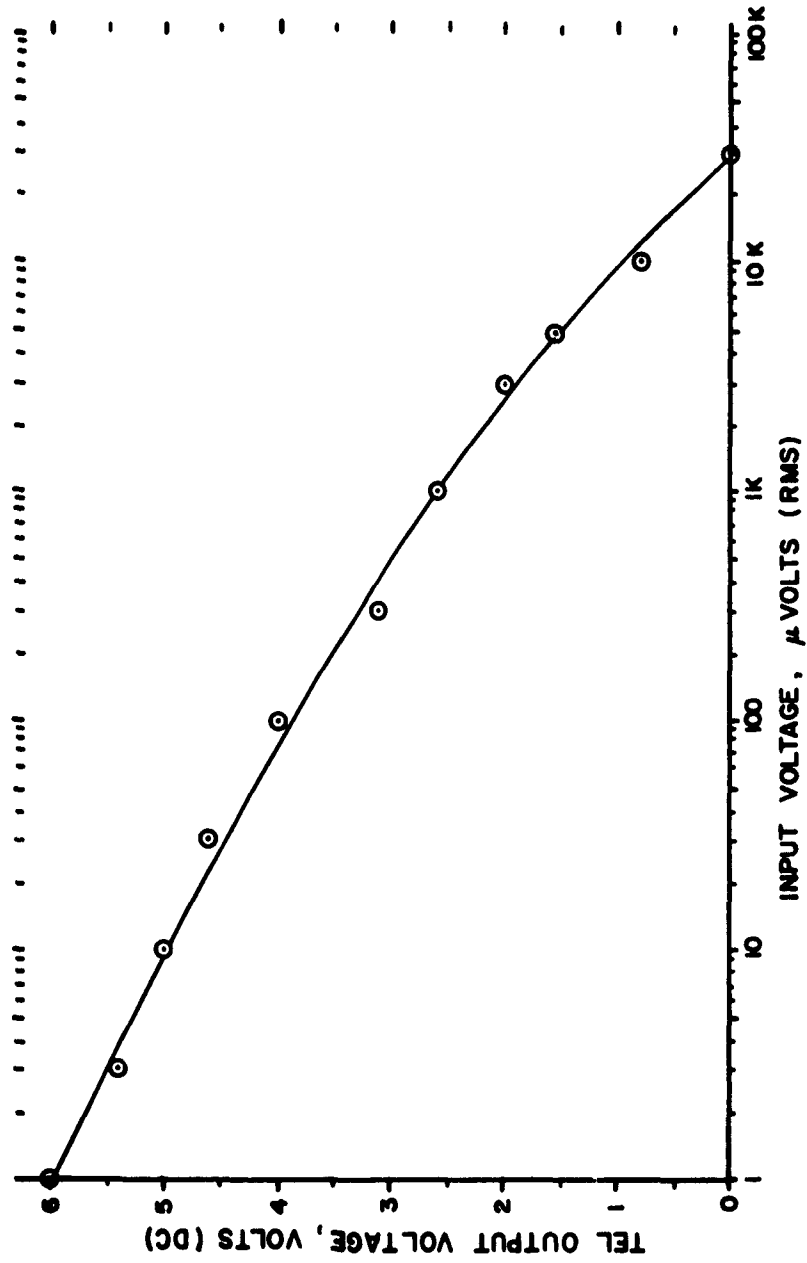
BANDWIDTH AND CENTER FREQUENCY VS.
 INPUT VOLTAGE FOR 100 KC/S DETECTOR

FIGURE 11



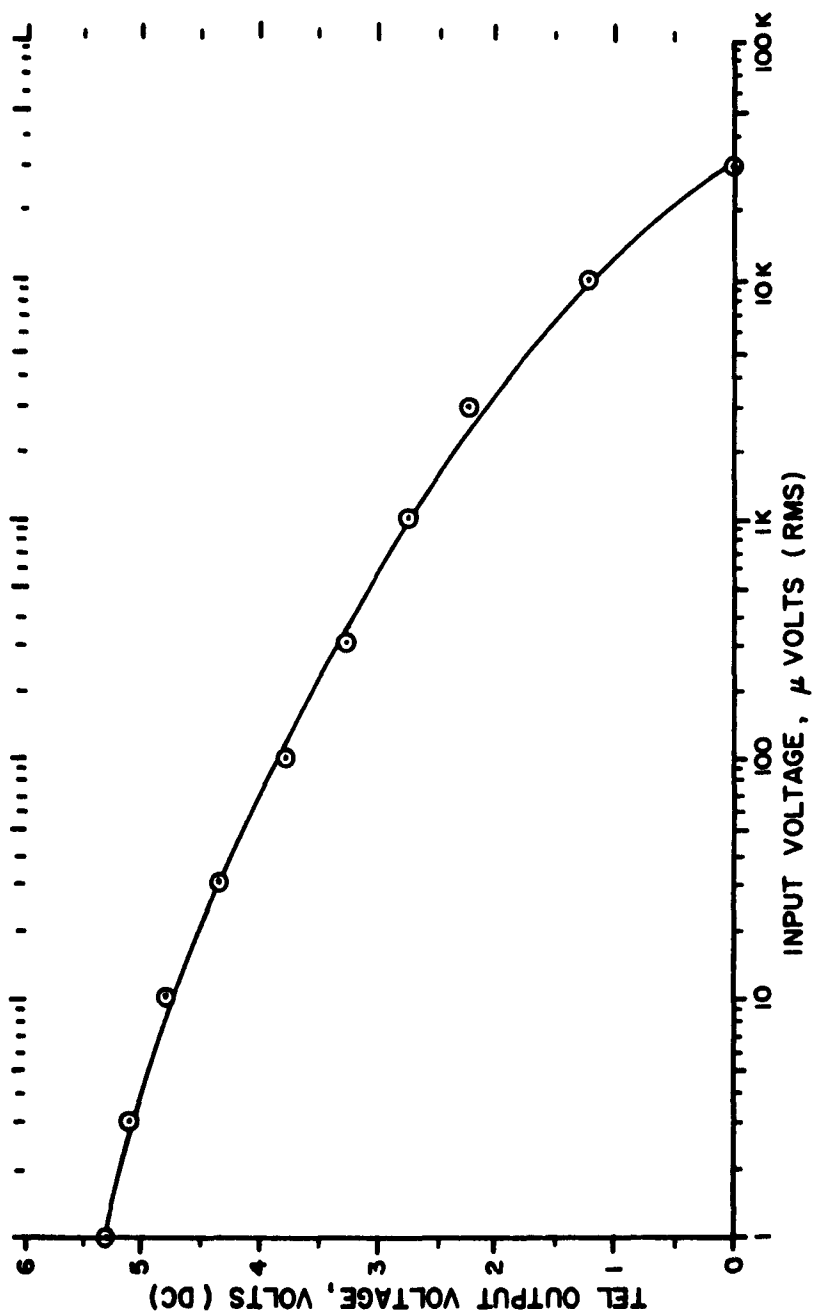
BANDWIDTH AND CENTER FREQUENCY VS.
 INPUT VOLTAGE FOR 512 KC/S DETECTOR

FIGURE 12



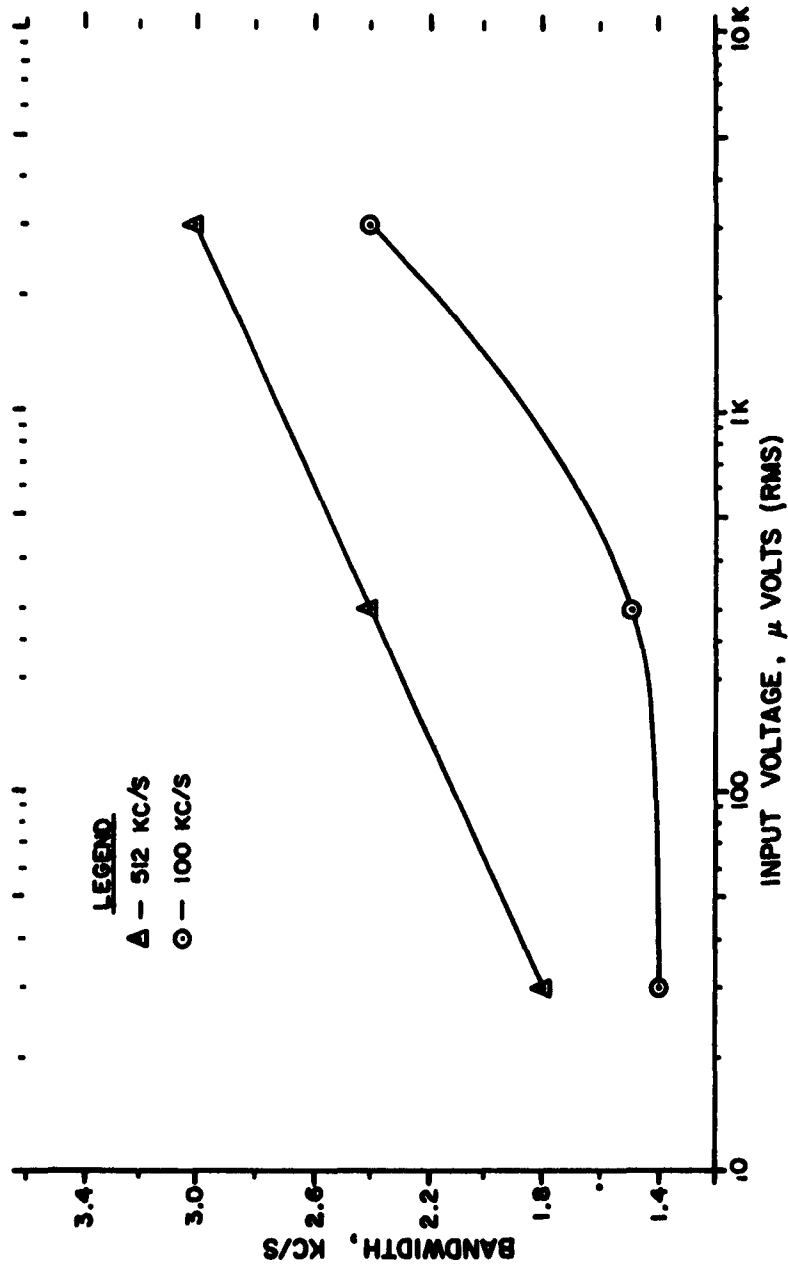
100 KC/S STATIC DETECTOR CHARACTERISTICS

FIGURE 13



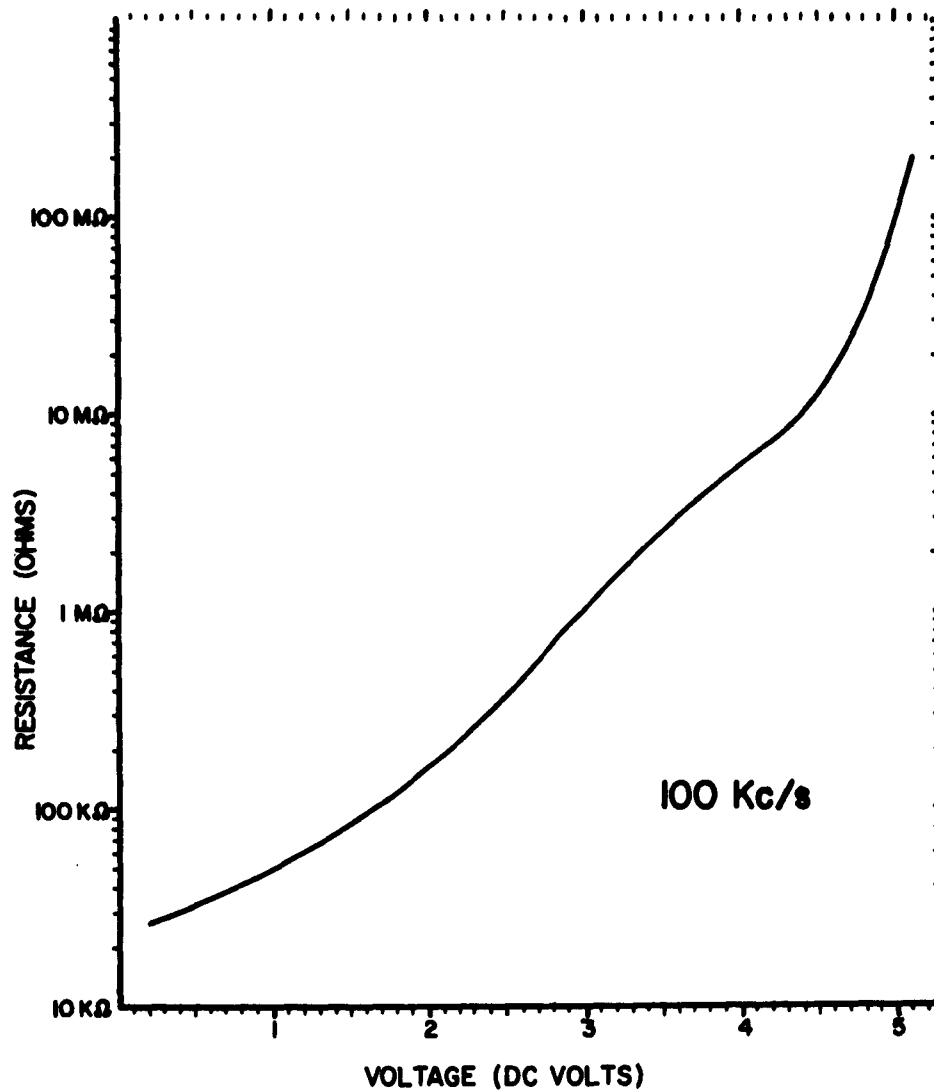
512 KC/S STATIC DETECTOR CHARACTERISTICS

FIGURE 14

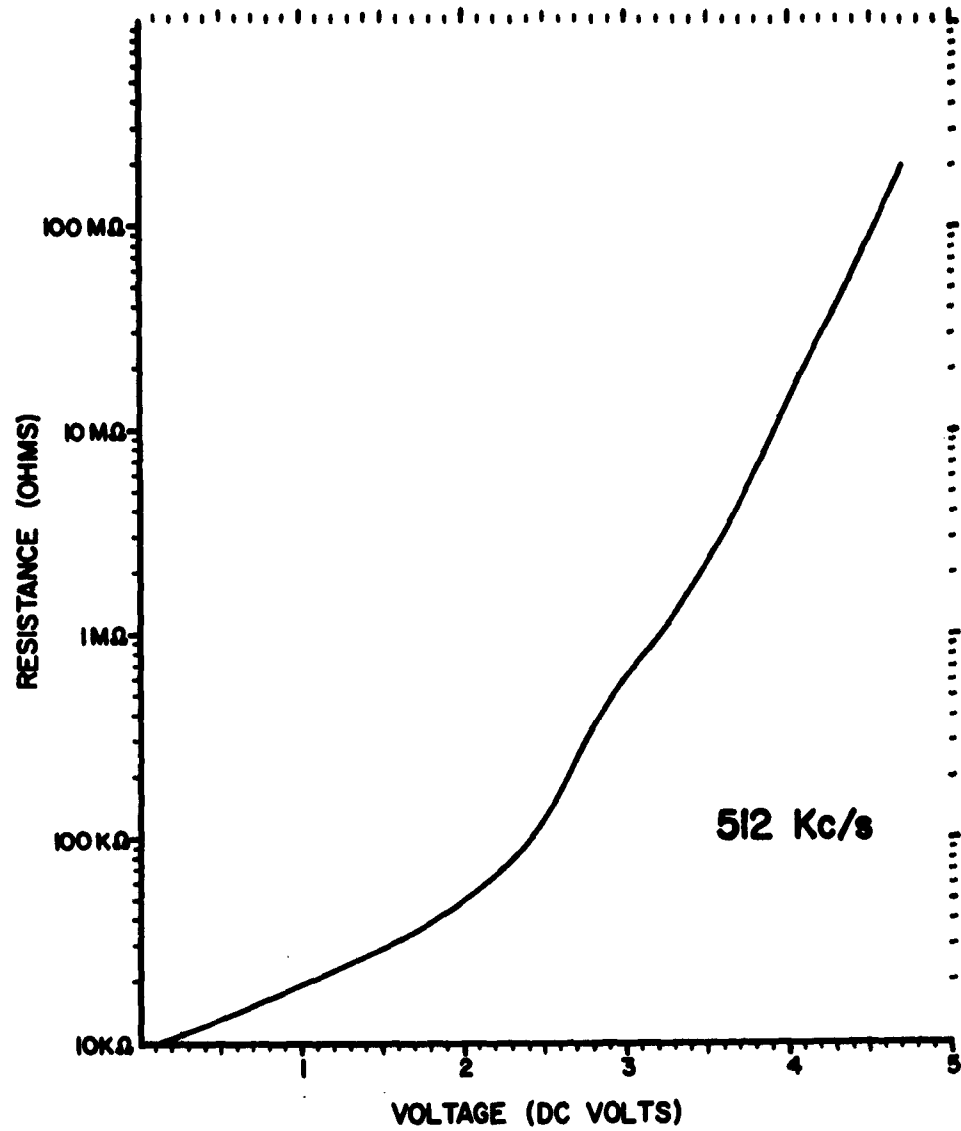


A. G. C. BANDWIDTH VS. INPUT VOLTAGE
FOR 100 KC/S AND 512 KC/S DETECTORS

FIGURE 15

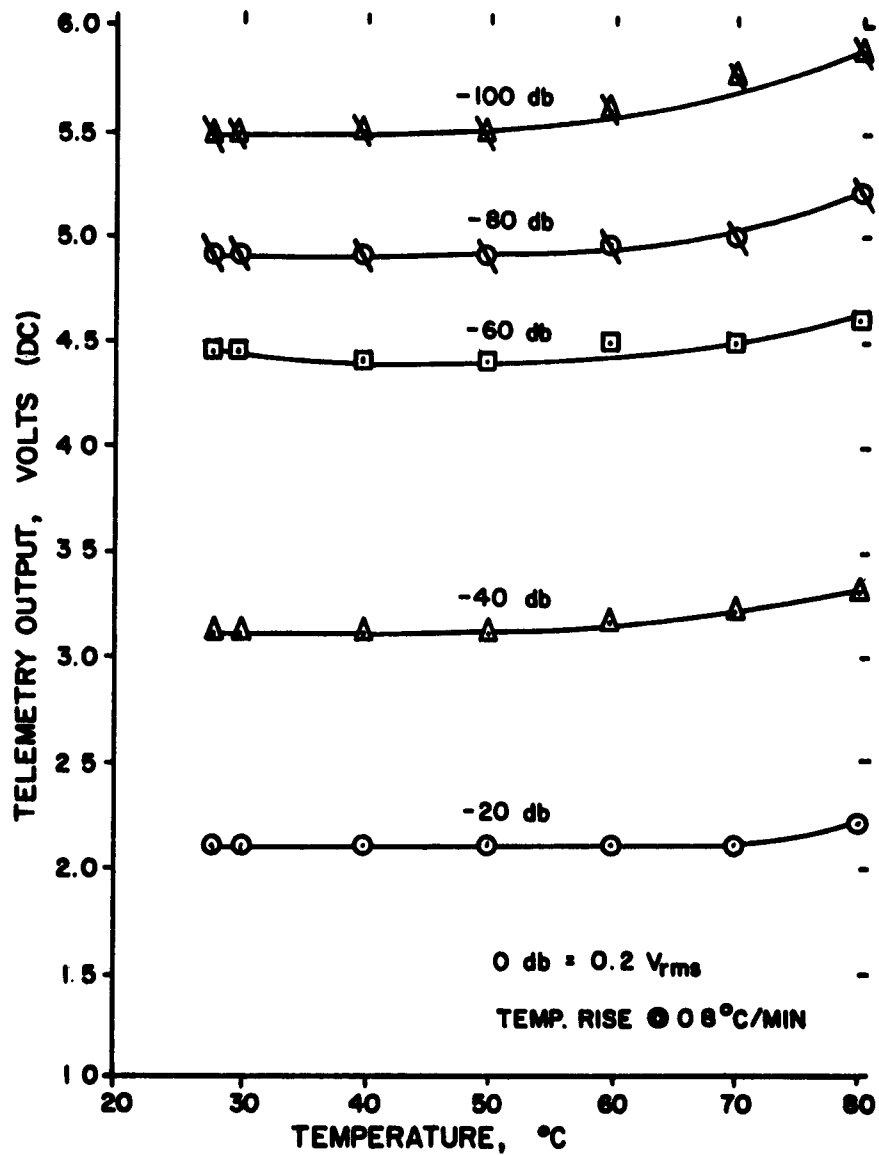


**DYNAMIC CHARACTERISTICS
OF RF PROBE UNIT
RESISTANCE VS. AGC VOLTAGE
FIGURE 16**

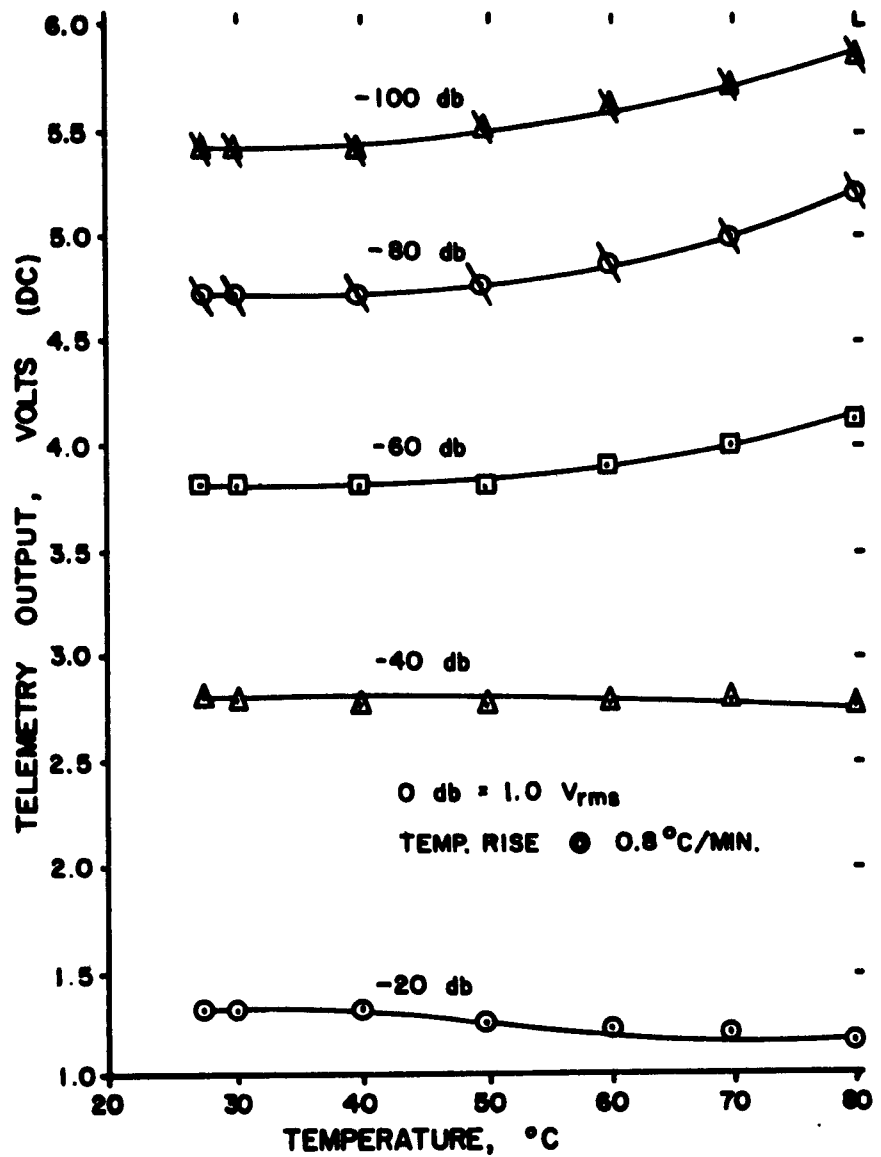


**DYNAMIC CHARACTERISTICS
OF RF PROBE UNIT
RESISTANCE VS. AGC VOLTAGE**

FIGURE 17



OUTPUT CHARACTERISTICS OF
100 KC/S DETECTOR WITH TEMPERATURE
FIGURE 18



OUTPUT CHARACTERISTICS OF
512 KC/S DETECTOR WITH TEMPERATURE

FIGURE 19

512 kc/s detectors are shown in Figure 11 and 12 respectively.

2.4.1 Automatic Gain Control

The automatic gain control voltage is derived from two sources. One source is the 1N34 germanium diode connected to the plate circuit of the third amplifier. The second source is the voltage developed by grid current in the second amplifier. The diode detector works for all values of input level while the grid current source is effective only during large amplitudes of grid voltage at the second stage. A smooth convergence of the sources is evidenced and shown in the static detector characteristics of the 100 kc/s and 512 kc/s detectors given in Figures 13 and 14. The broadening of the AGC bandwidth as a function of input voltage for both detectors is shown in Figure 15.

2.4.2 Probe Characteristics

Figures 16 and 17 show the dynamic characteristics of the RF probe unit for each frequency. The resistance in ohms is the value of the unknown resistance present across the insulated section of the nosecone. The DC voltage represents the telemetry input voltage for a four decade range in shunt resistance across the insulator.

2.4.3 Temperature Effects

Temperature characteristics of the 100 kc/s and 512 kc/s detectors for given input levels are shown in Figures 18 and 19. A temperature rise of 0.8°C per minute was

considered slow enough to ensure that all components in the detectors were at the same temperature during the measurements. A 7.5% change in output voltage in the worst possible case for a temperature rise of 50°C is satisfactory, since it is doubtful that during the short flight time the ambient instrumentation temperature change will be as much as 10°C .

2.4.4 Packaging

The detectors are mounted on printed circuit boards. All of the small components, excluding the electron tubes, are held rigidly in place with clear epoxy. The electron tubes are mounted in spring clip holders, and their flexible wire connectors are supported in the same clear epoxy. Some of the construction details are similar to those shown in Figure 23. The null detectors are bolted to a channel frame which is fastened to a heavy aluminum base-plate. This base-plate serves as a means of fastening the container to the rocket pay-load support frame and in addition contains plugs for power and telemetry input. The entire capacity probe unit which includes the bridge circuit, detectors and a zener regulated plate-voltage supply is enclosed in an aluminum cylinder which fits tightly over the channel frame and is bolted fast to the mounting base-plate.

3.0 Propagation Experiment

The propagation experiment is designed to measure the field strength along two axes at the rocket of a low frequency

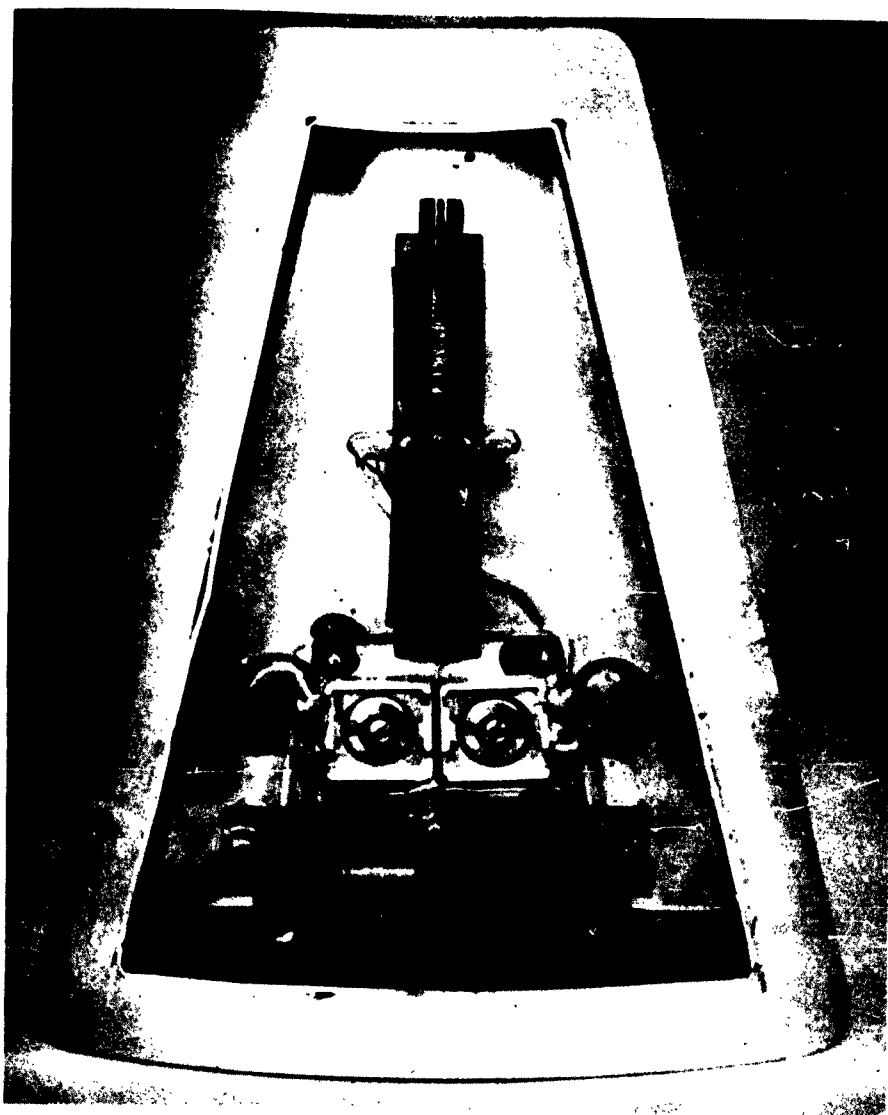
signal transmitted from the ground. Two ferrite loop antennas are mounted along and perpendicular to the main axis of the rocket and feed individual receivers. The receivers have logarithmic characteristics and their outputs are fed to telemetry channels 3 and 4 (1.3 kc/s and 7.35 kc/s channels respectively). Thus, the telemetry records provide information concerning the variation of the field strength as the rocket travels through the D and E region of the ionosphere.

3.1 Low Frequency Receiving Antennas

The antennas are loops wound on a ferrite core. The ferrite rods were taken from J. W. Miller Co. No. 2003 miniature antenna loops. No. 10/41 Litz wire was wound on the core to an inductance of 2.2 mh. The measured Q of the antennas was approximately 4. This low value of Q produces a bandwidth of approximately 50 kc/s for an antenna tuned to 201 kc/s and results in little influence of temperature on the antennas.

The antenna box (Figure 20) mounts flush on the lower inside portion of the nose cone and is covered with a high temperature fiber glass resin manufactured by the National Vulcanized Fiber Corp., Wilmington, Delaware. The cover can be seen on the photograph of the nose cone given in Figure 3.

Variable capacitors are also mounted in the antenna box and provide a means of tuning the antennas from outside



ANTENNA BOX

FIGURE 20

the rocket up until the time of firing. The antenna box is encapsulated with Eccofoam F2, manufactured by Emerson and Cumming's Corp., Canton, Mass. This foam provides both structural support to the antennas and insulation from friction heating of the rocket surface. There is no apparent effect on the Q of the antennas due to the fiberglass cover or the Eccofoam encapsulation.

Measurements of the equivalent length of the antennas were made with the antennas mounted in the rocket. A test transmitter was placed approximately 50 feet from the nose cone. The field strength of the signal at each antenna was measured with a Stoddard type NM-20B field strength meter. The receiver output was then compared with the output of the receiver when connected to a standard signal generator. The equivalent lengths of the antennas were found to be of the order of 6-8 cm.

The antennas are connected to their respective receivers through two coaxial cables approximately 3 feet long.

3.2.0 Receivers

The receivers used to detect the low frequency signal transmitted from the ground to the rocket are vacuum-tube

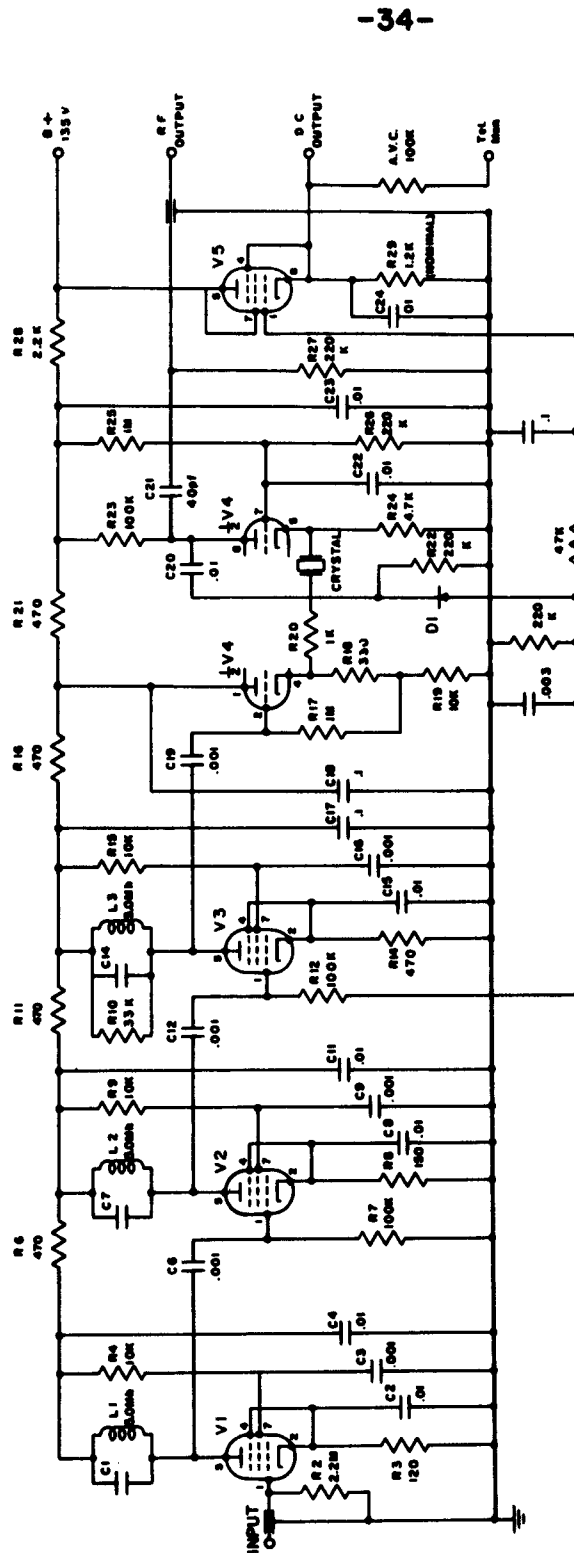
type similar in design to the 512 Kc/s REDD circuits. The use of vacuum tubes rather than transistors is due to the original scheduling of the rocket firings, the availability of some components, and experience with the REDD receivers. In this way development was reduced to a minimum.

A circuit diagram of a 201 Kc/s receiver is shown in Figure 21, and its corresponding input-output characteristics are made to follow as nearly as possible a logarithmic law ($E_{out} \propto \log E_{in}$). The minimum and maximum detectable signal at the input to the first stage is approximately 0.4 μ volts and 1mv respectively. The receivers are tuned RF amplifiers and utilize a crystal filter to control the bandwidth which is approximately 40 c/s. AGC, applied to 2 stages, and saturation of the second stage at high input levels are used to increase the detectable signal range.

Figure 23 illustrates a low frequency receiver mounted on its aluminum housing.

3.2.1 Bandwidth

The bandwidth of the receivers is limited by a crystal filter. The filter is fed from a cathode-follower and the output is connected to the cathode of a triode which operates as a grounded grid amplifier. In this configuration the crystal filter is matched at both ends by a low-impedence, thereby allowing only those frequencies for which the crystal is series resonant to pass through. At high input levels the filter loses some of its rejection capabilities and acts more

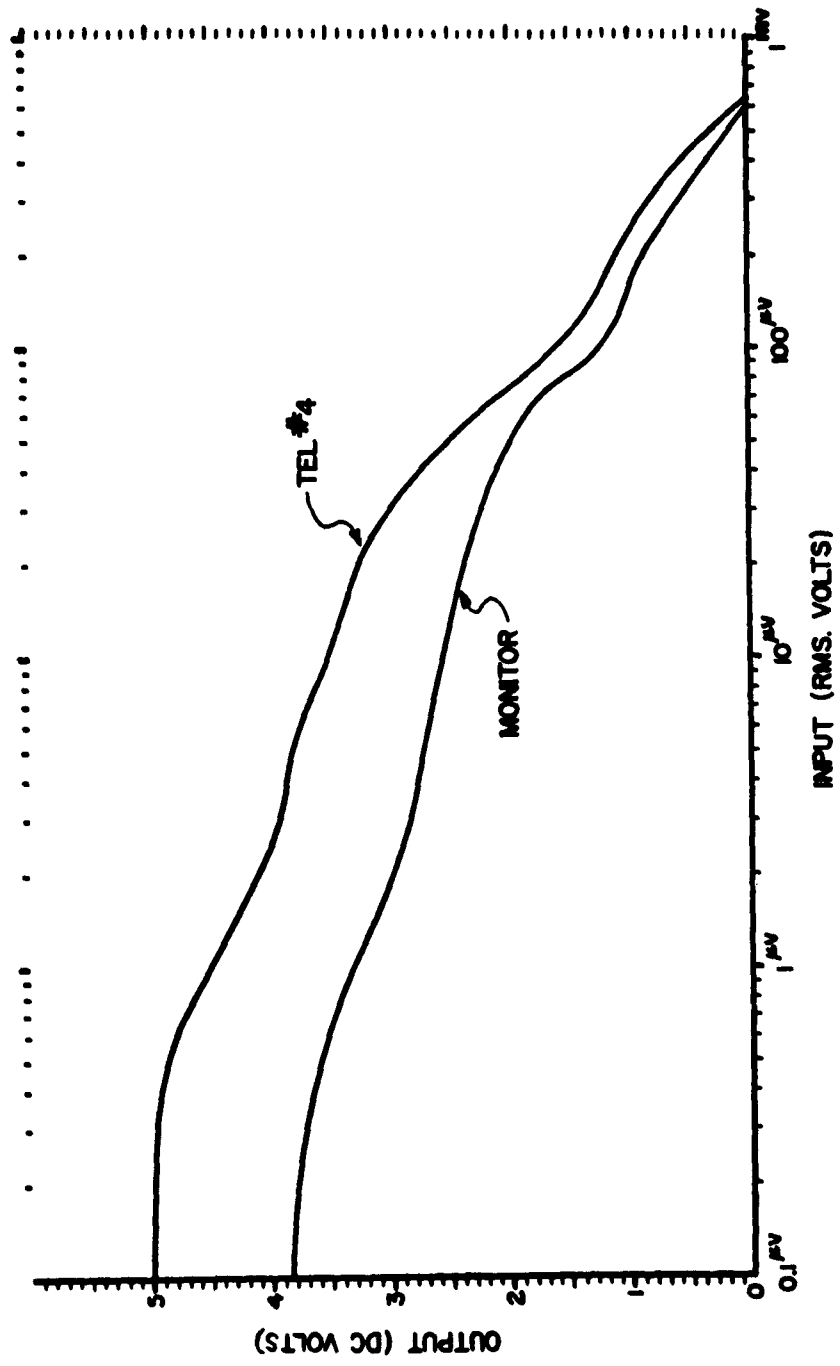


ALL RESISTORS IN OHMS, 1/2 WATT
ALL CAPACITORS IN μ F UNLESS
OTHERWISE INDICATED

C1, C7, C14 APPROXIMATE VALUE OF 90 pF

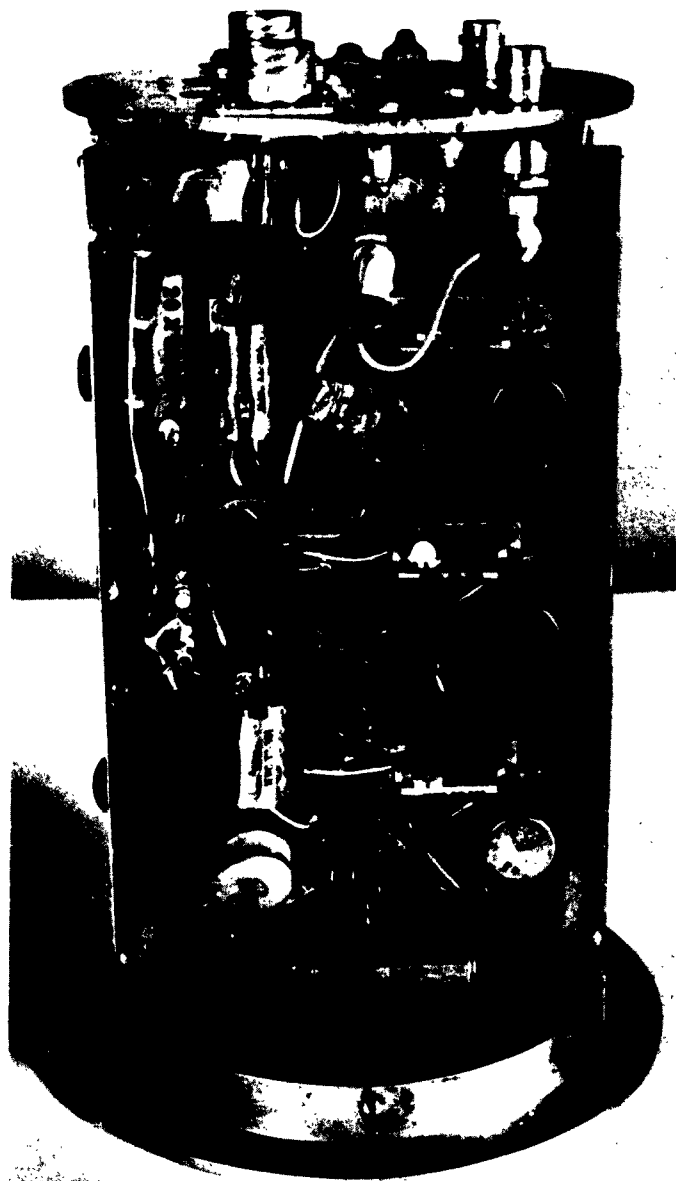
V1, V5 5699
V2, V3 5840
V4 6021
D1 1N34AG

SCHEMATIC DIAGRAM OF 201 kc/s RECEIVER
FIGURE 21



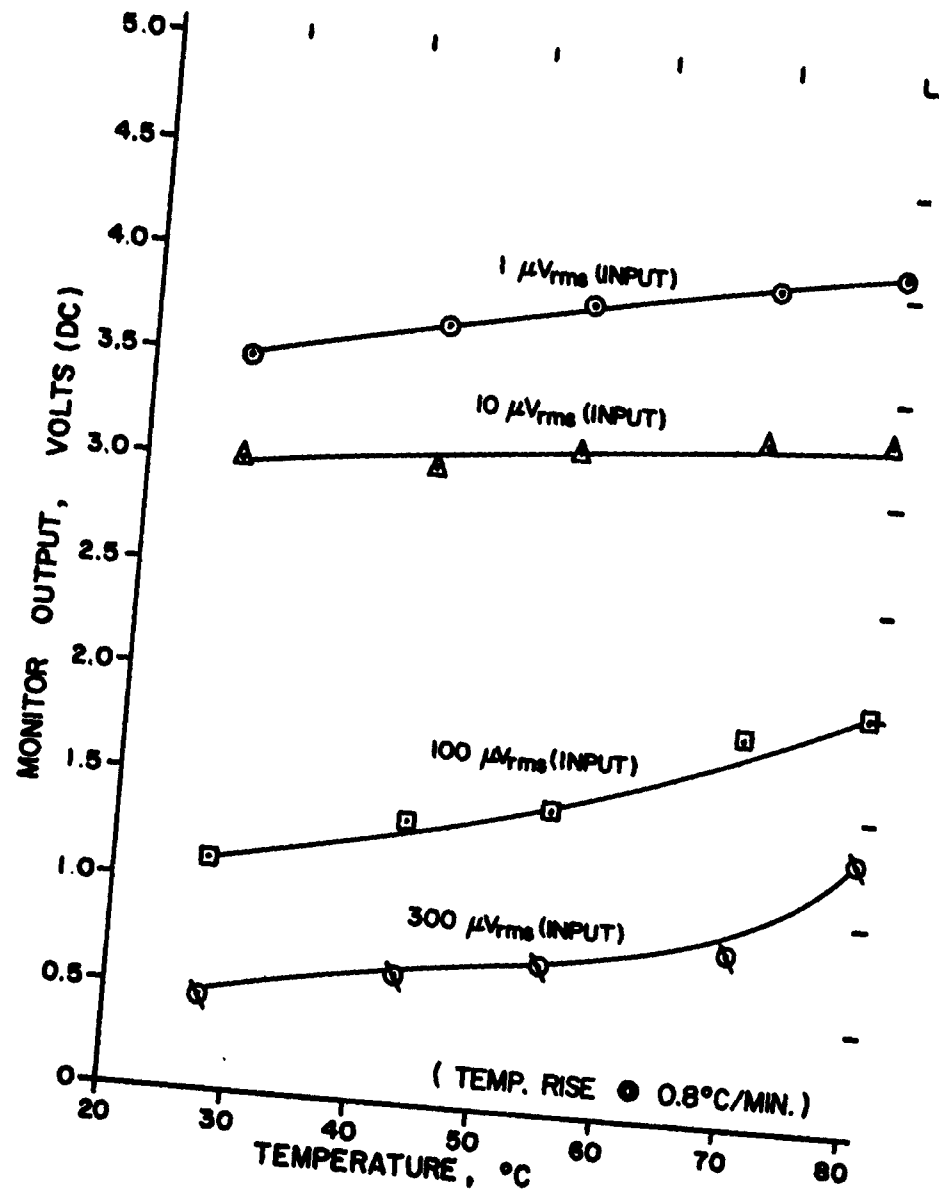
201 Kc/s RECEIVER AGC CHARACTERISTICS

FIGURE 22



ASSEMBLED RECEIVER ON FRAME

FIGURE 23



TYPICAL TEMPERATURE CHARACTERISTICS
OF 201 KC/S RECEIVER
FIGURE 24

like a capacitive coupler. A resistance placed in series with the crystal provides a means for adjusting the bandwidth.

3.2.2 Automatic Gain Control

AGC is applied to 2 stages by taking the RF output from the plate of the grounded-grid amplifier, converting it to DC, and applying the negatively derived voltage to the grids of the controlled stages. The proper amount of AGC voltage on each controlled stage to achieve the desired characteristics was determined empirically. The output voltage is obtained by connecting the AGC voltage to a triode-connected, semi-remote cutoff pentode in a cathode-follower configuration.

3.2.3 Temperature Characteristics

The temperature characteristics of a typical 201 kc/s receiver were measured for various fixed input levels over a range of temperature between 30 and 80°C. The results of the measurement are given in Fig. 24. These curves indicate that the receivers are more sensitive to temperature change at high input levels than at low input levels and that the rate of temperature dependence increases with increasing temperatures. During firing of the rocket the ambient temperature should be somewhere between 20°C and 40°C at Eglin AFB, and as is seen from the characteristics, this is the most desirable range in which to operate. The maximum change in output occurs at 100 μ volts input and is approximately 0.2 volts/20°C. or

0.01 volts/ $^{\circ}$ C.

3.2.4 Packaging

The receivers are printed circuit assemblies and are mounted on an aluminum rack which in turn is mounted in a cylindrical housing similar to that of the probe detectors. All components are rigidly fastened to the printed circuit boards by careful soldering. An epoxy resin is placed on any parts which may be prone to the vibration experienced during flight.

4.0 Power Supply

The basic DC power supply is obtained from a Yardney Silvercel battery pack of 8 type HR-4 cells connected in series which provides as much as 4 amperes for one hour at 12 volts. The power supply output is distributed by the control box to all the instrumentation.

The 130 volt supply required by the receivers and probe detectors is derived from the Yardney battery pack through a Sorensen type QC12/130-0.23 DC-DC converter. The circuit diagram of the converter is shown in Figure 25.

Voltage regulation in each of the units is achieved with zener diodes. A capacitive filter is connected across the terminals of the battery pack in order to suppress spikes which are generated in the converter and fed back from it.

4.1 HR-4 Silvercels

The HR-4 silvercel is a rechargeable high-rate battery

having a nominal capacity of 4.0 ampere-hours at an average voltage of 1.5 volts. Typical discharge characteristics are shown in Fig. 26.

A summary of the manufacturer's specifications applicable to the experiment follow:

Open-Circuit Cell voltage: 1.86 volts

Nominal Voltage Under Load: 1.5 volts

Recharging Cycle Life: 20-25 cycles at 1 hour discharge rate

Operating Life: 6 to 9 months

Operational Temperature Range: $+74^{\circ}\text{C}$ to -27°C

Resistance to Mechanical Stress: meets spec.

MIL-E-5272A

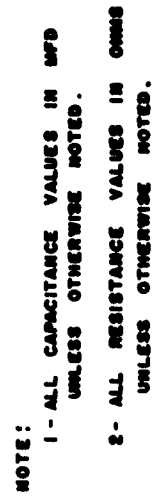
Electrolyte: Potassium hydroxide solutions

Charging Time: fully rechargeable within 10 hours

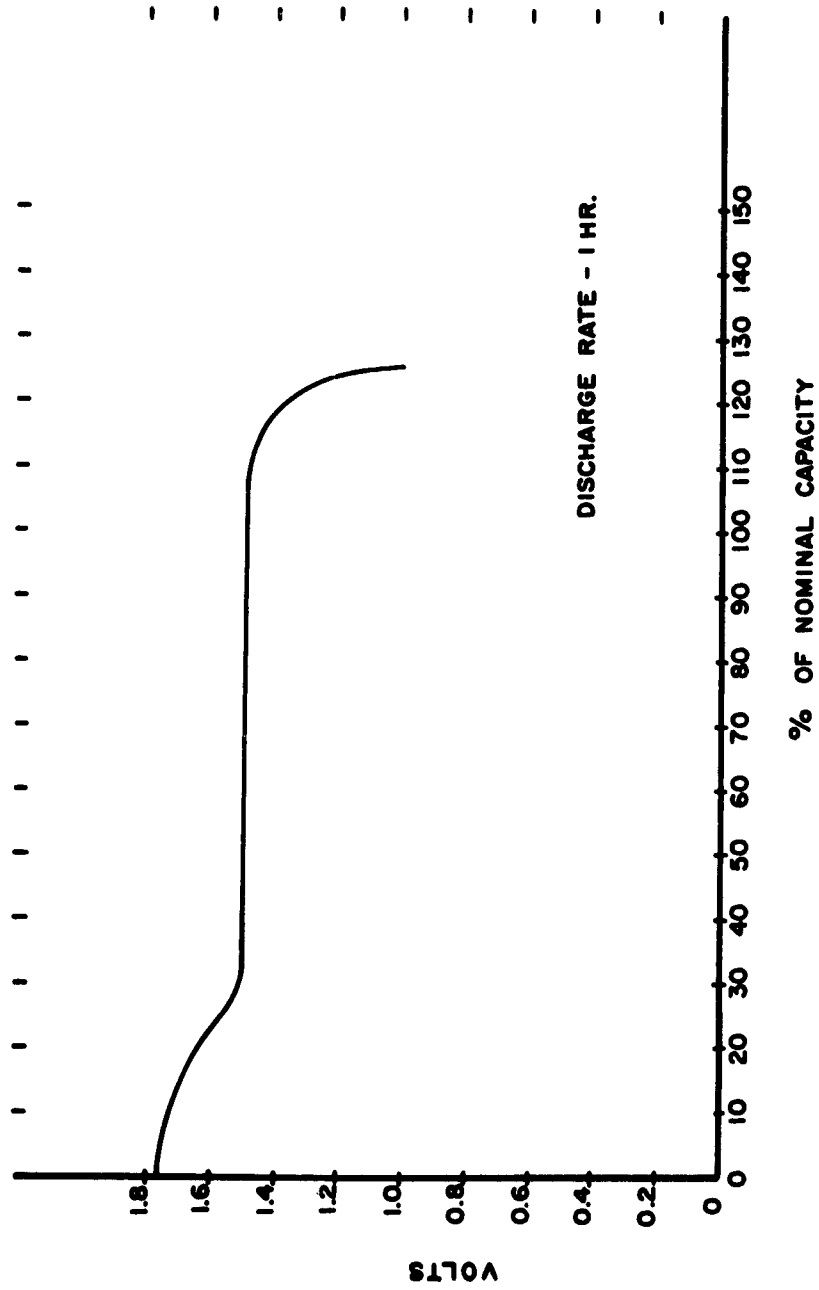
Charge Completion: indicated by a sharp rise in cell voltage (to 2.0 volts)

In addition, the silvercells exhibit very slight gassing during discharge or stand, and may be stored wet between $+40^{\circ}$ to -50°C and dry between $+75^{\circ}\text{C}$ to -65°C .

To guard against out-gassing of the batteries during flight, the batteries are housed in an air-tight container, shown in Figure 27. The capacitors, used to filter the spikes fed back from the converter, are also mounted in the battery box, and the whole unit is foam encapsulated. Figure 28 is a circuit diagram of the battery pack with its associated capacitor filter.



**SORENSEN DC TO DC CONVERTER
SCHEMATIC DIAGRAM
MODEL QC 12/130 - .23
FIGURE 25**

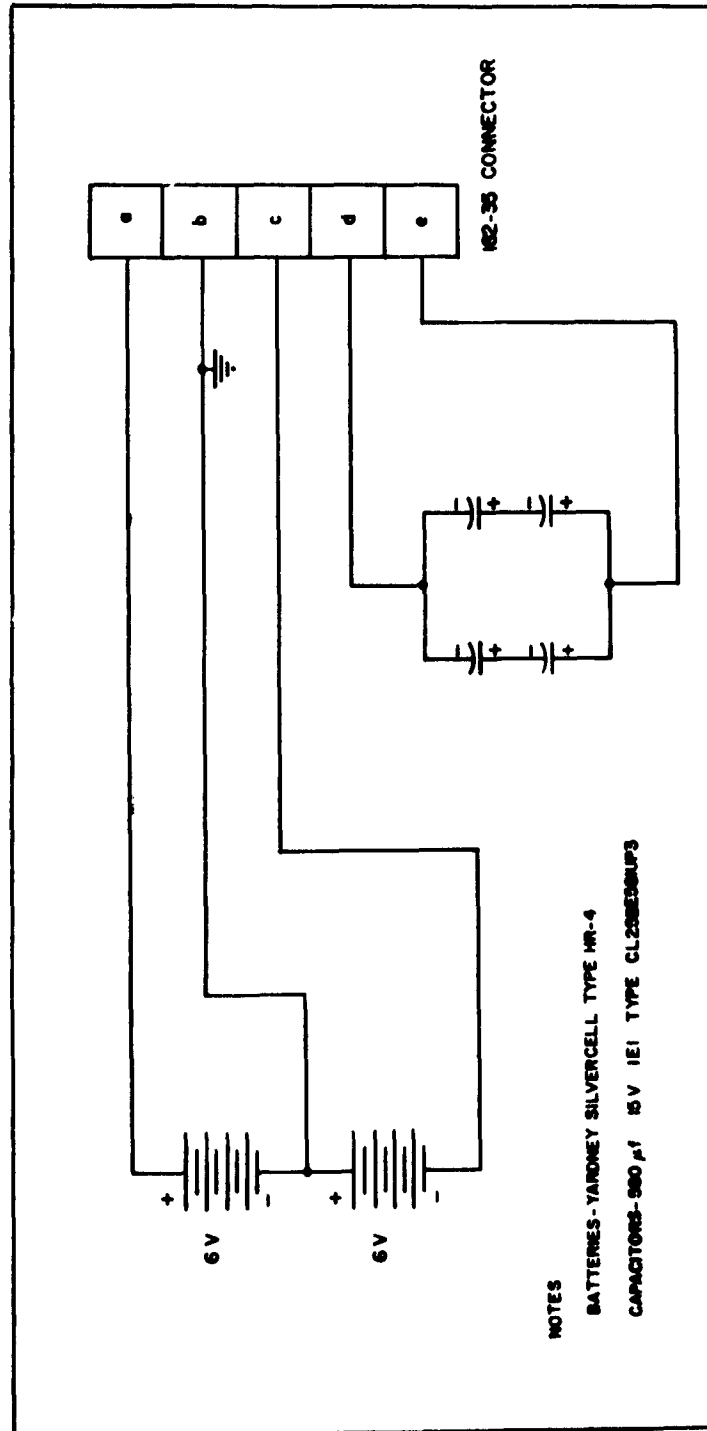


TYPICAL DISCHARGE CHARACTERISTICS OF YARNEY SILVERCEL

FIGURE 26



BATTERY PACK AND CONTAINER
FIGURE 27



4.2 DC-DC Converter

The DC-DC converter is a Sorensen type QC 12/130-0.23 which changes 12 volts at 3.0 amperes to 130 volts at 0.23 amperes. It is used to supply B+ voltage to the receivers and detectors.

5.0 Control Box:

The functions of the control box are as follows:

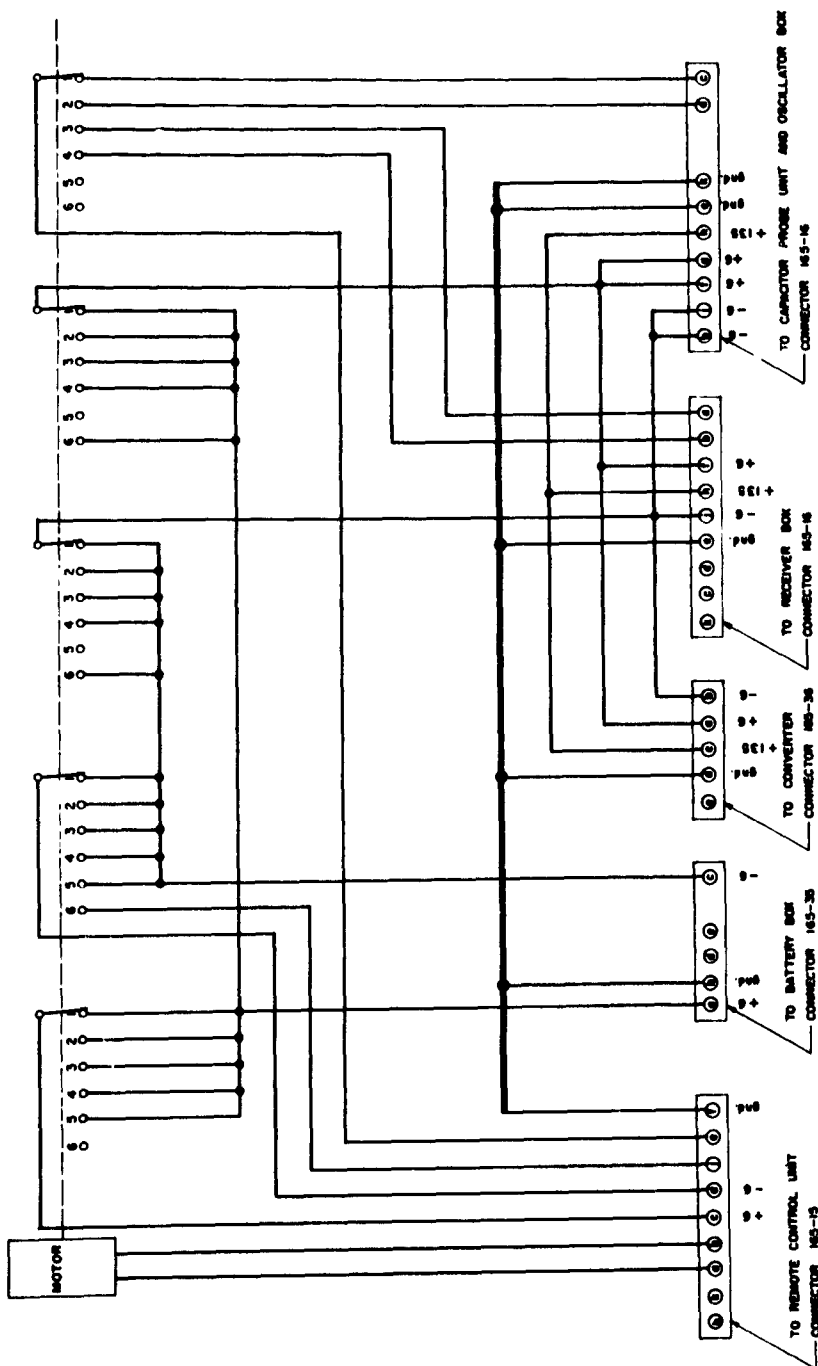
- 1.) Distribution of power from the battery pack and converter to all the units.
- 2.) Provides remote battery charging and use of ground-based power.
- 3.) Provides sequential monitoring of the inputs of the four telemetry channels during countdown.

A wiring diagram of the control unit is given in Figure 29. The switch was manufactured by Tech Laboratories, Palisades Park, N. J. It is a ganged 5 deck, single-pole, six position rotary switch and is energized by the remote control unit.

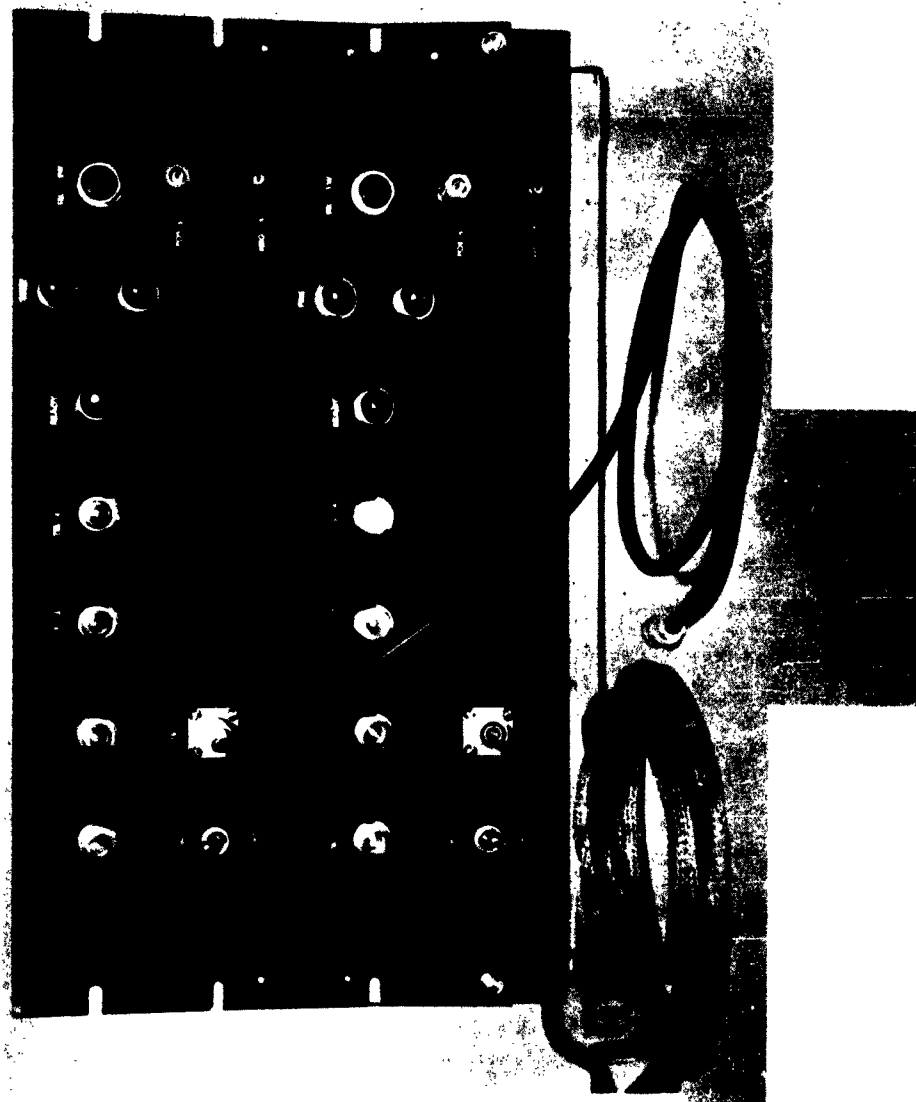
6.0 Remote Control Unit

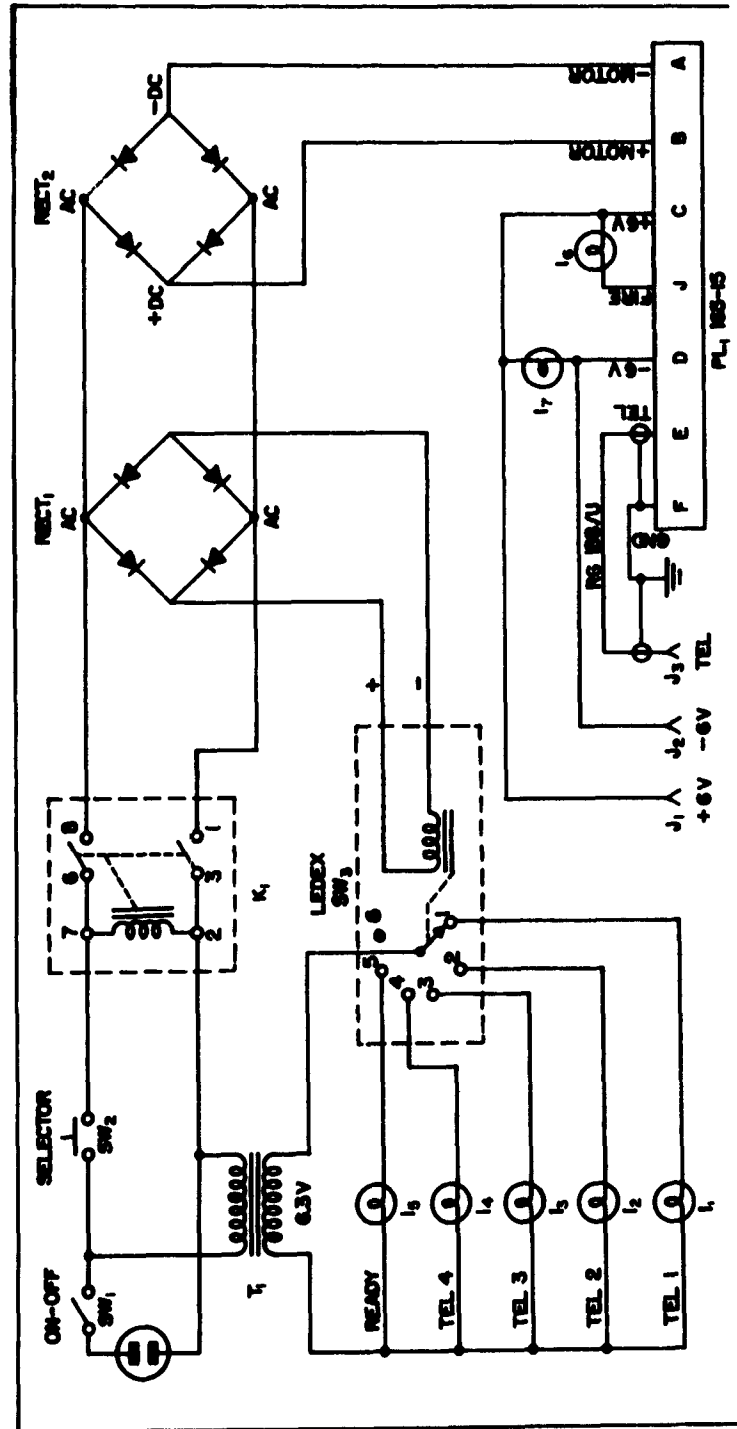
The remote control unit is used in the blockhouse to monitor the payload performance prior to launch. Figure 30 is a photograph of the remote control unit. A circuit diagram is given in Figure 31. Two identical units are contained in one rack mounted chassis to provide a back-up unit, should one fail during countdown.

The unit controls the position of the rotary switch in



CONTROL BOX WIRING DIAGRAM
FIGURE 29





REMOTE CONTROL UNIT WIRING DIAGRAM

FIGURE 31

the payload control box. By this switching technique it is possible to perform the following operations:

- 1.) Monitor telemetry channels 1,2,3,4.
- 2.) Supply block-house power for battery charging and pre-countdown equipment checkout.

The blockhouse wiring diagram of the entire Black Brant experiment is given in Figure 32, indicating where in the system the remote control unit functions.

7.0 Vibration Testing of Instrumentation:

Each electronic assembly was tested to the following vibration specifications.

A.) Main Axis. (L.C.)

- | | |
|---------------------------|--------------|
| 1.) 0.1 "Double Amplitude | 5-35 c/s. |
| 10 g | 35-3000 c/s. |
| 2.) 0.3" Double Amplitude | 5-35 c/s |
| 20 g | 35-3000 c/s. |
| 3.) 0.5" Double Amplitude | 5-35 c/s |
| 30 g | 35-3000 c/s. |

B.) Horizontal Axes (x & y)

- | | |
|---------------------------|--------------|
| 1.) 0.1" Double Amplitude | 5-35 c/s |
| 5 g | 35-3000 c/s. |
| 2.) 0.5" Double Amplitude | 5-35 c/s |
| 10 g | 35-3000 c/s |

BLACK BRANT EXPERIMENT BLOCKHOUSE AND ROCKET PULLAWAY WIRING DIAGRAM

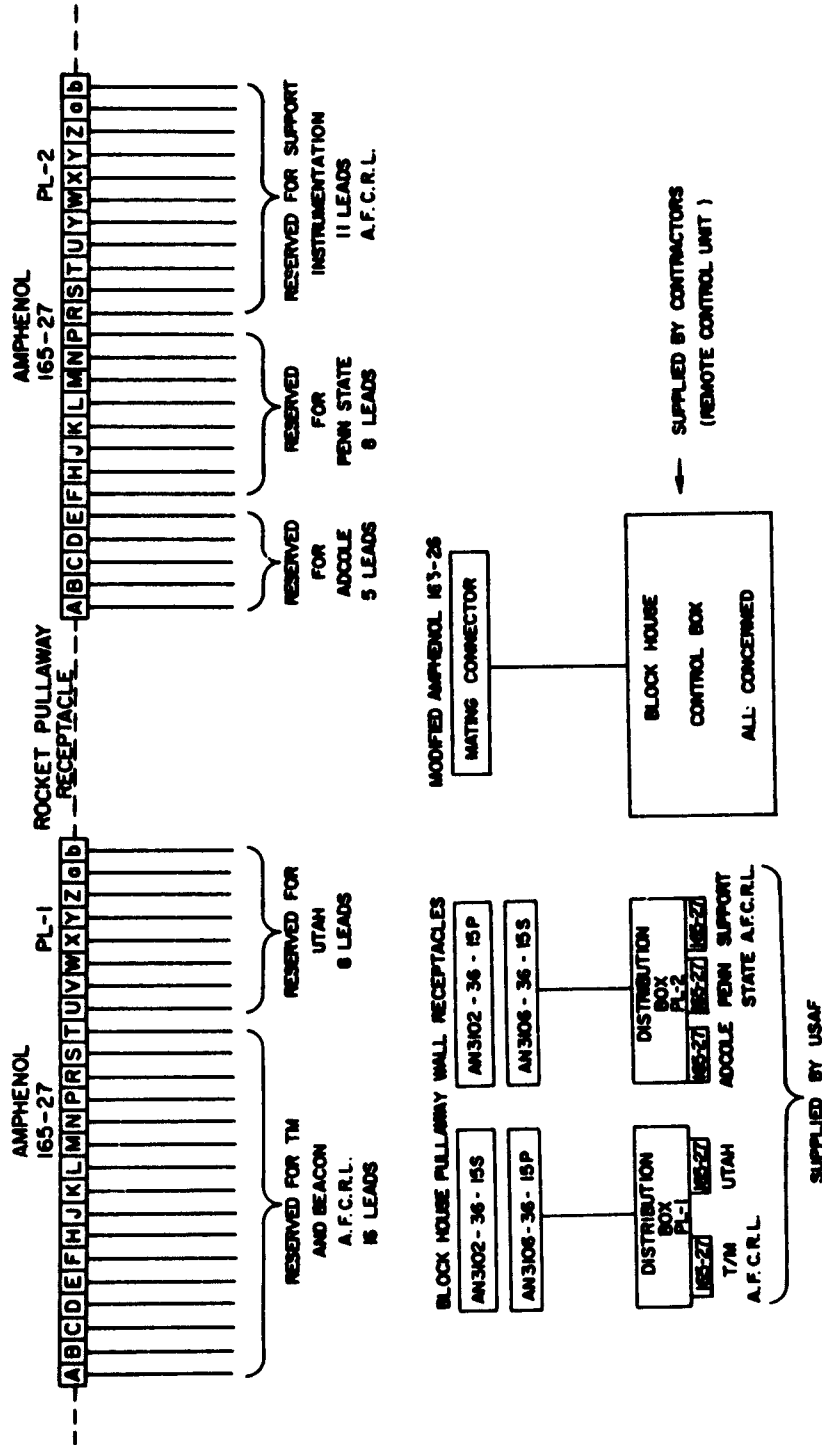


FIGURE 32

The frequency was swept logarithmically over the range 5 to 3000 c/s in 5 minutes during each test. No attempt was made to meet any Mil Spec or rocket environmental specifications, since none were called for.

During each sweep of frequency, any resonances were noted and the unit under test was vibrated at the resonant frequencies at the test level for a period of one minute. The electrical and mechanical operation of each unit was monitored during the tests. After the completion of each test, the units were removed from their fixtures, covers were removed, and a visual check of all components, wires, screws, etc., was made before reassembling and continuing the tests. The vibration testing was performed at the Lockheed Environmental Test Laboratory, Plainfield, N.J.

8.0 Countdown Procedure

The countdown procedure is divided into two separate tests, a hangar check and a pre-launch check.

8.1.0 Hangar Checkout

It is assumed that arrangements have been made with the agency which operates the transmitter to be used for the propagation experiment, and the times at which cw transmission at maximum power is required is known. The hangar checkout takes place prior to placing the rocket on the launcher.

8.1.1 Conductivity Experiment

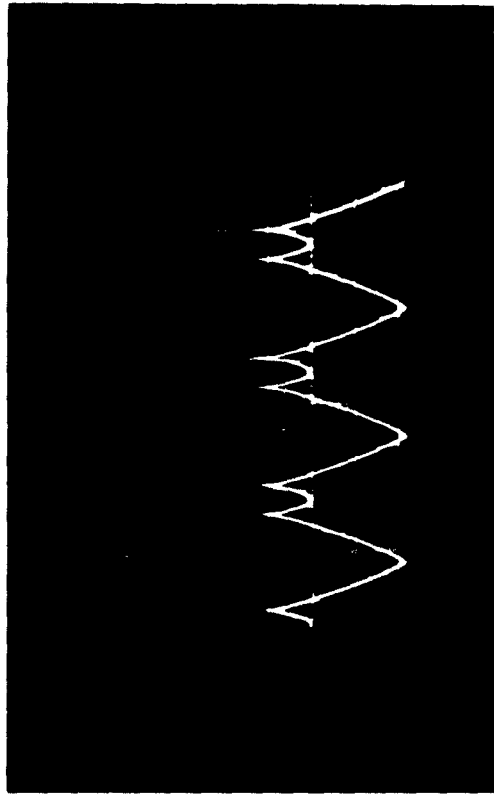
The following procedure is to be performed during hangar checkout:

- 1.) Connect remote control unit to rocket umbilical plug and turn equipment on using internal power supply of 12 volts.
- 2.) Observe telemetry channels 1 and 2 at the control unit for waveform of the type shown in Figure 33.
- 3.) Adjust the variable capacitors so that the spacing between nulls of the observed waveform are such that a range of measurable capacitance is suitable for the particular ionospheric conditions.
- 4.) Balance the bridge by adjusting the trimpots for maximum voltage at the nulls.
- 5.) Record the voltage at the nulls for various known shunt conductances covering the range 10^{-4} mhos to 5×10^{-7} mhos.
- 6.) With no shunt conductance across the nose cone insulator, record the spacing between nulls for various known shunt capacitances between 0 and 30 pf.
- 7.) Check the power supply voltage. It should be 12 volts under full load. If it isn't, the experiment should be delayed until the batteries are recharged to an open-circuit voltage of 16 volts.
- 8.) Recheck the bridge balance and if correct apply a quick setting epoxy to the trimpots and variable capacitors. Replace the access cover.

8.1.2 Propagation Experiment

The hangar checkout of the propagation experiment equipment consists of the following procedure:

- 1.) Remove antenna box cover and tune the antennas to the desired frequency.



TYPICAL OUTPUT WAVEFORMS
OF 100 Kc/s AND 512 Kc/s DETECTORS

FIGURE 33

- 2.) Apply a quick-setting epoxy to the tuning capacitors to prevent any de-tuning because of vibration during flight.
- 3.) Operate the equipment from the internal battery supply.
- 4.) Place the antenna calibration box over the exposed antennas in the nose cone and secure it by at least two of the cover screws. Connect the crystal test oscillator to the antenna calibration box.
- 5.) Turn the oscillator on. Observe variations in the telemetry monitor outputs of channels 3 and 4 when the attenuator settings on the oscillator are changed. With oscillator turned off, an output of approximately 5 volts should be observed on both channels. With the oscillator on and no attenuation, the receivers should be saturated, and the telemetry output voltage zero. Intermediate attenuation settings should produce outputs between 0 and 5 volts. Note: The 5 volts output assumes an infinite impedance voltmeter; any other measuring device should take into account a 100 k Ω resistor which connects the telemetry output to the telemetry monitor output.
- 6.) Repeat (7) of the Conductivity Experiment.
- 7.) Remove the aluminum calibration box containing the ferrite loop and replace the antenna box cover.
- 8.) Turn off all equipment.

8.1.3. Power Supply Check-out

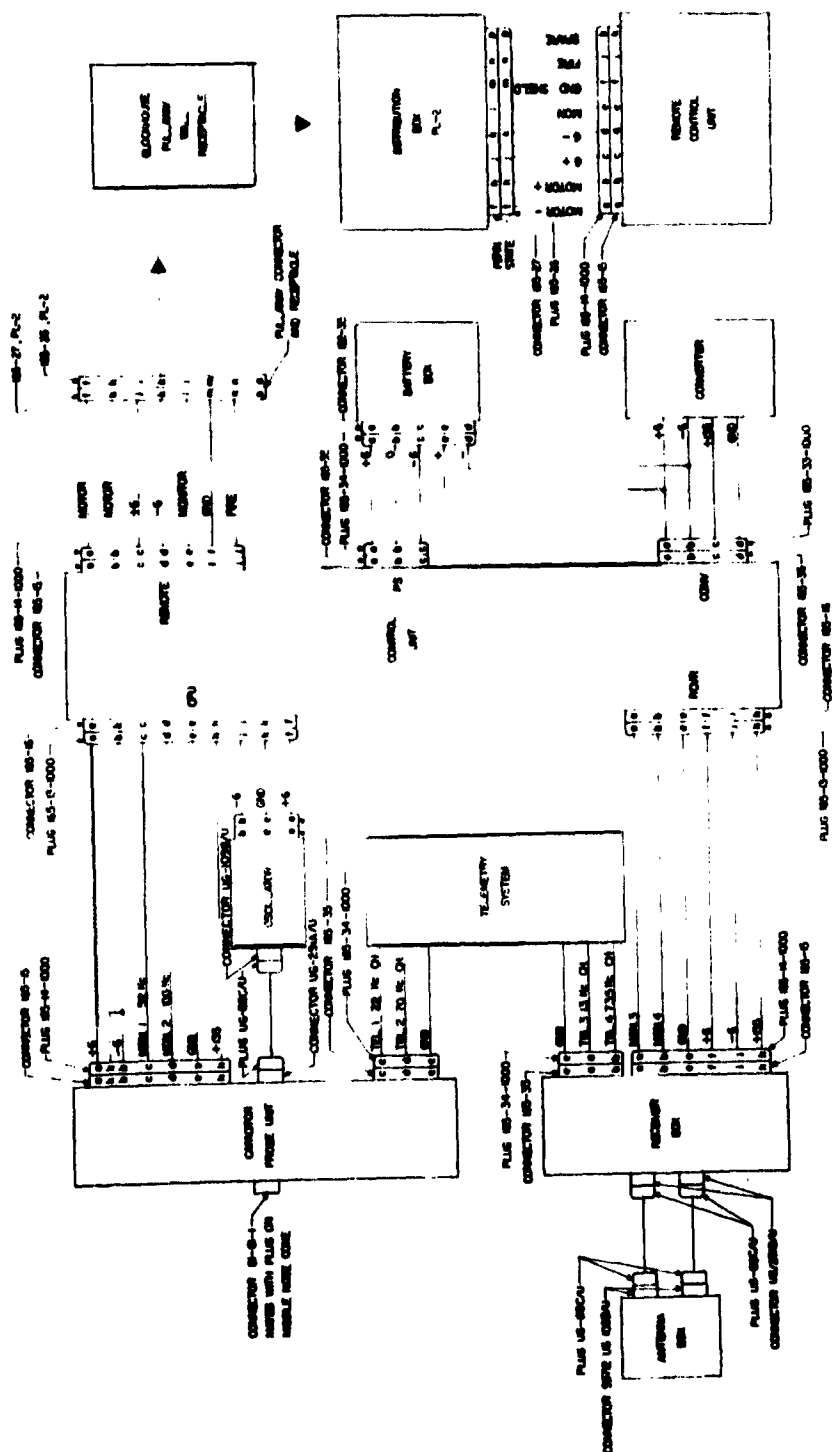
Prior to mounting the rocket on the launcher, a final test of the battery voltage should be made. The battery pack should be fully charged to an open-circuit voltage of 16 volts.

8.2.0 Pre-Launch Checkout

The following procedure should be carried out prior

to launch while the rocket is on the launcher (Power may be internal or external):

- 1.) Parallel the internal power supply test jacks on the remote control unit with a DC power supply of sufficient voltage and current capacity (depends on length of cable between block-house and launcher) to operate all instrumentation in the payload. Turn the equipment on at T-30 minutes.
- 2.) Compare the outputs of telemetry monitor channels 1 and 2 with the output of the appropriate telemetry channels (22 kc/s and 70 kc/s respectively). Both should look similar to Figure 33.
- 3.) Note the effect of placing any foreign objects near the insulated portion of the nose cone. A change in the position of the nulls should occur. If possible place a 100 k Ω resistance across the insulator; decrease of the voltage at the nulls should occur.
- 4.) Using a Stoddard type NM-20B field strength motor measure the field strength in the vicinity of the propagation experiment antennas. Compare this value with that calculated using the telemetry output voltage and an equivalent length of 7 to 8 cm. for the loop antennas. Antenna orientation, reflecting objects etc., must be considered in making this test where the purpose is simply to demonstrate that the propagation experiment is working at the time of launch.
- 5.) Compare the remote control unit outputs (Channels 3 and 4) of the receivers with the telemetry outputs (1.3 kc/s and 7.35 kc/s respectively). Both should be constant, except for some noise riding on the signal.
- 6.) When the above procedure has been carried out, turn-off the equipment and measure the open circuit battery voltage. If it is below 16 volts, charge at a rate of 100 ma. up until T-5 minutes.
- 7.) Turn equipment on at T-5 minutes using the external supply up until T-1 minute.



INTERCONNECTION WIRING DIAGRAM FOR ROCKET INSTRUMENTATION

- 8.) At T-1 minute switch to internal supply and check outputs of telemetry monitors against their appropriate telemetry outputs.

Channels 1 and 2 - Output similar to Figure 33.
Channels 3 and 4 - Constant Outputs corresponding to the field strength at the launch site.

Figure 34 is an interconnection wiring diagram of the instrumentation in the rocket.

8.3 Equipment Required for Countdown

Following is a list of test equipment required at the hangar and blockhouse.

I. Conductivity Experiment

- 1.) Dual channel oscilloscope - Tektronix type 545, 516, or equivalent.
- 2.) Calibrating resistors and capacitors; $10\text{ k}\Omega \leq R \leq 200\text{ m}\Omega$, logarithmically spaced; $5\text{ pf} \leq C \leq 30\text{ pf}$, linearly spaced.
- 3.) Direct reading oscillograph:
DC to 2000 c/s; Amplifier (Z in $\approx 1\text{ M}\Omega$).
Honeywell type 906C or equivalent.

II. Propagation Experiment

- 1.) DC Power Supply - 10 to 30 volt; 0-5 amp.
- 2.) Field Strength Meter - Stoddard type NM-20B
- 3.) Crystal Controlled Test Oscillator (tuned to frequency of the experiment)
- 4.) Multimeter: Triplet type 630-A or equivalent.

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2. "Theoretical Determination of the Impedance Characteristics of a Capacitive Ionosphere Probe" - Herman, J. - Ionosphere Research Laboratory, Scientific Report No. 180, The Pennsylvania State University, March 1, 1963.